THE KANSAS UNIVERSITY SCIENCE BULLETIN.

Vol. VIII, No. 7—July, 1913.

(Whole Series, Vol. XVIII, No. 7.)

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THE BIOLOGY OF SOME KANSAS EUMENIDÆ.....*Dwight Isely.*

PUBLISHED BY THE UNIVERSITY,

LAWRENCE, KAN.

Entered at the post-office in Lawrence as second-class matter.

5-838

KANSAS STATE PRINTING OFFICE.
W. C. AUSTIN, State Printer.
TOPEKA. 1914.

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THE KANSAS UNIVERSITY
SCIENCE BULLETIN.

Vol. VIII, No. 7] JULY, 1913. [Whole Series Vol. XVIII, No. 7.

The Biology of Some Kansas Eumenidæ.

BY DWIGHT ISELY.

(Submitted in partial fulfillment of the requirements for the degree of master of arts.)

Plates XXXIV to XXXVII.

INTRODUCTION.

THIS paper is based on field observations and collections made by the author while connected with the Biological Survey of the University of Kansas, in northwestern Kansas during the summer of 1912. Specimens of fully developed insects, upon which biological notes were based, were identified by means of the Snow Entomological Collections. The caterpillars, parasitic larvæ, and cocoons, were identified to species or family, as the case might be, by Francis X. Williams, assistant curator of the Snow Entomological Collections.

The drawings of nests were made by the author, first in the field, and then were copied in the laboratory. They were inked by Miss Orrel M. Andrews, a graduate student in entomology. Four drawings of wasps, made from specimens in the collection, are entirely her work.

The author takes this opportunity to thank Prof. S. J. Hunter, head of the department of entomology, to whom he is indebted for general oversight of the work and much helpful criticism. He also wishes to thank Mr. Francis X. Williams for help in studying the Eumenidæ both in the field and in the laboratory; Mr. H. B. Hungerford, instructor in entomology, and Miss Ruby C. Hosford, a graduate student in the department, for reading and criticizing the manuscript; and Miss Orrel M. Andrews for assistance in illustration.

Purpose of Thesis.

An account of the biology of almost any wasp must be, for the most part, an account of nesting activities. Nest building and provisioning is the mother wasp's life work. Her interrelations with other insects, the food habits of her offspring, and consequently, to a large extent, her economic importance, are directly connected with her nest and its contents. A study of the larva, its habits and modifications in structure, refers back to the nest. Those activities which in no way relate to the nest—the mother wasp's search for food for herself, her avoidance of perils daily, and the idle male's pastimes—those activities are but incidents in the story. The main plot centers about the nest.

The study of wasps, bees and ants owes much of its fascination to their nesting habits. The features in the accounts of their lives are more than growth and development. A range of talents—useless to ordinary insects—are demanded of them in the building and provisioning of their nests. Their ecology becomes more complex. The nest builders' lives are made purposeful; their chief aim becomes more than to eat and avoid being eaten. By this labor for their progeny a fascinating and highly developed display of instincts is called forth.

The Eumenidæ have received my special attention both because of their attractive habits and because of their convenience for study. The varied architectural skill of the eumenids makes them attractive, for within the group are potters, miners, masons, carpenters, and more or less degenerate builders. As solitary insects they offer advantages, in that the activities of the individual insect can easily be isolated and studied. This solitary habit also removes the opportunities for imitation, and thus makes instincts more clearly defined. In western Kansas the Eumenidæ is an important group, being well represented both in species and numbers.

A study of the nesting habits of Kansas Eumenidæ, then, is the chief burden of this paper. Nine species are to be discussed. So much is it a study of nesting habits, that no wasps whose nesting habits have not been observed are considered. However, with the account of nesting habits are notes on all the other activities of these nine wasps that I observed, and some notes on immature stages. In addition to the biological notes, I have included descriptions of the species discussed. I

have also added brief summaries of some of the literature available on the biology of the Eumenidæ.

In my study my purpose was only to study and record accurately the activities of these wasps. While the study of instinct is fascinating, it has not been my aim to accumulate evidence that would have a bearing on the theories of insect instinct and intelligence. Some data, however, relating to these theories have been collected, but their collection has been incidental and often accidental—it was a by-product of the work.

Systematic Position and Distribution.

The family Eumenidæ is placed by systematists with the social Vespidæ and the parasitic Masaridæ in the superfamily Vespoidea. Members of this superfamily can readily be distinguished from the fossorial wasps by the anterior wings, which are folded in plaits when at rest. Because of the club-shaped antennæ, the family Masaridæ is set apart from the other two families, which have more or less filiform antennæ. A single spur on the middle tibia, instead of two spurs, and unidentate tarsal claws, are the chief morphological differences between the Eumenidæ and the Vespidæ. These differences are not considered by all to be of sufficient importance to be used in the division of families. Sharp says: "We anticipate that the Eumenidæ and the Vespidæ will ultimately be found to constitute one family." De Saussure did not consider the morphological differences of sufficient importance to make even two distinct tribes of the solitary wasps and the social wasps; he divided them because of the difference in habits.

In habits there is little likelihood of confusing these allied families. The social wasps, like the social bees, have three castes—queens, drones, and workers. The brood cells in the nests of the community are built in combs. The solitary wasps have only two forms, and all the work is done by fully developed females. There is no division of labor, for each wasp builds its own nest. Both groups are predacious, but, according to De Saussure, the solitary wasps are the more so.

The Eumenidæ, according to Sharp, are distributed widely over the world in temperate and tropical regions. Representatives of the genus *Odynerus* are found even on the isolated Hawaiian Islands. About eight hundred species have been described.

Review of Literature.

The habits of the Eumenidæ vary widely. Even after my summer's study on the Biological Survey, I had no conception of the extent of variation, for previous to that summer I had made no study of the group either by reading or otherwise. After returning, a review of the available literature on the subject greatly widened my view and cast light on many details that I had entirely overlooked. Therefore, before beginning an account of my limited observations of a single summer I shall briefly summarize the work of others from various parts of the world, paying special attention to American observers.

De Saussure[1] says that the members of the genus *Zethus* by their habits seem to establish a "lien" between the Odynerinæ and the social wasps. He writes: "Certain species (of *Zethus*) manifest a tendency toward social habits. They form small agglomerations of nests, which resemble a little the irregular nests of bumblebees, but grouped yet more confusedly. But there always prevails this difference between cells formed by the social and those made by the solitary Hymenoptera, that the first have a cylindrical inner space, while the second are rather extended masses which are not in regular juxtaposition, so that they seem to be more like spheres and ellipsoids joined together than cells constructed side by side on a general plan. In other words, the solitary never seek to form a comb, although they sometimes form an agglomeration of cells."

In the genera *Zethus* and *Eumenes*, according to Ashmead,[2] are potters. They build globular cells of clay and mud, which are attached by a pedicel to a twig. The cell of *E. fraternus* is usually attached beneath the large leaves of the scrub palmetto. According to Doctor Harris, it feeds upon canker-worms in Massachusetts. In Florida it feeds on other small caterpillars. From these cells, in Florida, were bred *Phippiphorus dimidiatus.*

An instructive summary of the habits of a number of eumenids is given by Sharp.[3] His account of nesting habits of *Eumenes* is as follows.

1. Syn. Am. Wasp Sol., pp. 13-14.

2. Psyche, May, 1894, pp. 76-78

3. Sharp; Cambridge Nat. Hist., vol VI pp. 72-78.

Fabre has sketched the habits of a species of *Eumenes*, probably *E. pomiformis*. This *Eumenes* constructs with clay a small vase-like earthenware vessel, in the walls of which small stones are embedded. This it fills with food for the young. The food consists of caterpillars to the number of fourteen or sixteen for each nest. These caterpillars are believed to be stung by the parent wasp (as in the case of the fossorial Hymenoptera), but complete evidence of this does not seem to be extant, and if it be so, the stinging does not completely deprive the caterpillars of the capacity of movement, for they possess the power of using their mandibles and of making strokes or kicking with the posterior part of the body. It is clear that if the delicate egg of *Eumenes* or the delicate larva that issues from it were placed in the midst of a mass of this kind it would probably suffer destruction; therefore, to prevent this, the egg is not placed among the caterpillars, but is suspended from the dome covering the nest by a delicate thread, rivaling in fineness the web of the spider, and, being above the mass of food, it is safe. When the young larva leaves the egg it still makes use of the shell as its habitation, and eats its first meals from the vantage point of suspension. Although the mass of the food grows less by consumption, the little larva is enabled to reach it by the fact that the egg shell splits up into a sort of a ribbon, and thus adds to the length of the suspensory thread, of which it is the terminal portion. Finally the heap of caterpillars shrinks so much that it can not be reached by the larva even with the aid of the augmented length of the suspensory thread; by this time, however, the little creature has so much increased in size and strength that it is able to take its place amongst the food without danger of being crushed by the mass, and it afterwards completes its metamorphosis in the usual manner.

E. unguiculata, according to Perris,[3] constructs an earthen nest of irregular shape, containing three cells in one mass. *E. coarctata,*[3] a British species, attaches its nest to a twig of a shrub, while both previously mentioned species of this genus build their nests upon a flattened surface. *E. conica,* according to Horne,[3] constructs, in Hindustan, clay nests with very delicate walls. It is much attacked by parasites.

The likeness of the earthen nests of *Eumenes* to pottery has been spoken of by many authors. Howard[4] writes: "Prof. O. T. Mason says that certain beautifully shaped Indian vessels and baskets have precisely the same form as these cells, and he thinks that the observant aborigines may have deliberately copied the insect design."

4. Insect Book, p. 31.

Sharp's account of the habits of *O. reniformis,* drawn from Fabre, is as follows:

This insect (*O. reniformis*) provisions its cell with small caterpillars to the number of twenty or upwards. The egg is deposited before the nest is stocked with food; it is suspended in such a manner that the suspensory thread allows the egg to reach well down towards the bottom of the cell. The caterpillars placed as food in the nest are all curled up, each forming a ring approximately adapted to the caliber of the cell. Fabre believes these caterpillars to be partly stupefied by stinging, but the act has not been observed either by himself, Reaumur, or Dufour. The first caterpillar is eaten by the wasp larva from its point of suspension. After this meal has been made the larva is supposed to undergo a change of skin; it then abandons the assistance of the suspensory thread, taking up a position in the vacant chamber at the end of the cell and drawing the caterpillars to itself one by one. This arrangement permits the caterpillars to be consumed in the order in which they were placed in the cell, so that the one that is the weakest on account of its longer period of starvation is first devoured. Fabre thinks that all the above points are essential to the successful development of this wasp larva, the suspension protecting the egg and the young larva from destruction by pressure or movement of the caterpillars, while the position of the larva when it leaves the thread and takes its place on the floor of the cell ensures its consuming food in the order of introduction.

The species of *Odynerus*[2] are very subject to the attacks of parasites. They are destroyed to an enormous extent by Chrysididæ and by a fly, *Argyromœba sinuata.* Mr. R. C. L. Perkins observed *O. callosus* forming their nests in a clay bank and provisioning them with larvæ, nearly all of which were parasitized.

Perkins[3] has also observed some of the species of Hawaiian *Odynerus* make a single mud cell very like the pot of an *Eumenes,* but cylindrical instead of spherical. This little vessel is often placed in a curled-up leaf, which also shelters both spiders and young mollusks of the genus *Achatinella. O. punctum,* an East Indian species, according to Horne, nests in holes in door posts.

Many of the genus *Odynerus,* according to Ashmead,[2] appropriate galleries and cells made by different bees, and old mud daubers' nests. *O. errings,* in Florida, was observed making its nest in a door lock and in holes in a board fence. He also reared it in cells constructed in old oak galls of *Amphibolips cinerea.* Nine specimens of varying size were reared from a single gall. *O. allophaleralus* has been bred

from a gall of *A. confluens*. *O. fulvipes* was observed by Walsh building in a spool. *O. capra* was observed by Rev. T. W. Fyles provisioning its nest with the larch sawfly (*Nematus erichsonii*).

Odynerus is parasitized by Chrysididæ and by two or three ichneumonids. *Linoceras junceusi* is the only ichneumonid reared from them in this country. Walsh records having bred *Chrysis cœrulans* var. *bella* from *E. fraternus*. Cocoons of *Meteorus* and *Microgaster* have been found in cells of *Odynerus*. These may have been parasitic on caterpillars stored.

A. Davidson[5] gathered twigs of *Nama parryi* on Mount Wilson, California, which contained cocoons of *O. rufobasilaris*. The cocoons resembled finely grained caddis-fly cases. The outer surfaces were covered with sand; one end of the cocoon was truncate and the other rounded. The wasp, presumably, after provisioning each cell, adds a quantity of sand, which is afterward utilized by the larva. From ten cells four parasites (*Epistenia odyneri*, a chalcid) emerged.

O. reniformis is described by Dufour[6] as a wasp which burrows in a firm sand bank or in a clay terrace. An egg is laid at the bottom of each burrow, over which is placed green caterpillars, rolled together, yet living. Over the entrance of the burrow is an arcuate earthen tube. Dufour also described the habits of *O. lævipes*, which makes its nest in a dry bramble twig. This wasp also deposits its egg at the bottom of the cell and stores lively caterpillars above it.

Some of the genus *Odynerus*, according to Froggatt, build clay nests in various shapes, sometimes forming a finger-shaped row of clay cells, or rounded, cup-shaped chambers.

Observations on the nesting habits of five species of *Odynerus* are recorded by the Peckhams.[7] Three of these wasps nested in plant stems, one excavated a burrow in the ground, and the fifth made her nest in the mouthpiece of a horn.

O. perennis nests in July in raspberry and blackberry stems and partitions the cell with mud. In one cell were sixteen caterpillars, nearly one-third of which were dead.

A one-celled nest of *O. conformis* and a two-celled nest of *O. anormis* were found in stalks. Both nests were freshly provisioned, and in all three the egg was hung from the side

5. Psyche, vol. VII, p. 335.

6. Ann. Sci. Nat., ser. 2, vol. 11; 1838. Transl. by Verhœff, Ent. Nach., XIX, p. 49.

7. Wasps, Solitary and Social, pp. 89-95.

about one-third way down. In the nest of *conformis,* from which all but one of the caterpillars had fallen out of the cell, the egg hung loosely against the wall. "In the other nests," the account reads, "the lower part was packed tightly with sixteen small larvæ, upon which lay the egg, supported in a horizontal position, although attached to the side wall exactly as *conformis,* and above were eight more caterpillars, the whole forming a compact mass shut in by the usual partition of mud. So closely were they crammed in, that after counting them we were unable to get them all back again, and although motionless in their narrow quarters they became quite active when relieved from pressure. This is an entirely different arrangement from that of *O. reniformis* (described by Fabre), and since the larva is in contact with the caterpillars from the moment of hatching, the manner of the egg-laying has no significance in relation to the safety of the young.

Conformis, upon hatching, sloughed off the skin but remained attached to it, thus doubling the length of the thread by which it hung. The larvæ of *anormis,* upon hatching, broke from their attachment. They cocooned on the fifth day after hatching.

O. vagus was noted bringing pellets from a "sharp-edged" hole in the ground, dropping these ten or twelve inches from the burrow. This wasp was much disturbed by a red-headed match stuck in the ground two inches away from her burrow. For half an hour she refused to work until the offending object was removed.

A three-celled nest of *O. capra* was found in the mouthpiece of a tin horn. The cells contained a larva and a supply of very lively caterpillars, of which ten were in the cell most lately formed. One egg was found in another cell before it was provisioned. In four days the larva made its appearance, sloughing off the skin, and being free to crawl away.

Habits of two eumenids, *O. dorsalis* and *O. arvensis,* which I have studied, have been described by Mr. Carl Hartman in a bulletin published by the University of Texas, entitled "Observations on the Habits of Some Solitary Wasps of Texas."[8] These observations were made near Austin, Tex., during the summer of 1903.

Mr. Hartman writes: "*O. dorsalis* builds pretty mud cells on the ground, choosing a place hidden from view by a clump of

8. Bul. Univ. Tex., No. 65, pp. 6-10.

grass. The cells are broadly spindle shaped, pointed at one end, which is left open until the cell is stored. The chambers do not touch each other for more of their length than is necessary for their mutual agglutination. This almost entire independence of the cells entails a considerable waste of building material as compared with the habit of *Pelopæus cenentarius*, which builds its cells side by side in rows and tiers of rows."

A day's work with *O. dorsalis* is to provision one cell and construct another. The newly constructed cell is used as a resting place for the wasp herself during the first night.

In order to take a picture of the nest, Mr. Hartman pulled away some grass blades and set up his camera. This disturbed the wasp very little. "After once flying away for a minute," he writes, "and circling about once or twice, she settled and placed the caterpillar in the nest. . . . This done, she cleaned her antennæ and flew away without seeming to take her bearings."

Very small caterpillars—cotton worms—were stored. Of seven found in one cell four responded perceptibly to stimulation. The author believes that *Odynerus* occasionally takes a caterpillar for her own delectation. He also observed this wasp picking up unwary ants that passed too near her as she was lying in her cell one morning before going to work.

From six cells four wasps emerged in thirty-nine days each. The length of the stage for the egg and larva together was twenty days. The other two wasp larvæ were killed by mites.

I shall quote nearly the whole of Mr. Hartman's notes on *O. arvensis*. He writes:

This species of *Odynerus* does not possess the architectural skill of its cousin just described. Its home is not such an elaborate domicile, built, as it were, for show as well as for use, but consists of any convenient crevice in a wall or fence post. The nest is completed by closing the opening of the crevice with mud, much after the fashion of *Trypoxylon*. I have made a few observations on two nests of this *Odynerus;* those on the conditions of the caterpillars found are of particular interest. In general the following facts do not justify Fabre's conclusion, which he based on the habits of *O. reniformis*.

At noon August 4 a female *arvensis* was closing her nest in the niche of a brick wall. A few days before a *Trypoxylon* had emerged from the very niche now intended to be the cradle of another wasplet. I immediately opened the nest and drew out eight caterpillars, all of which were alive—six of them, in fact—so lively that they wriggled around in the small vial to which I had transferred them. I found no egg at first, but looking carefully into the dark recess, I discovered the egg suspended

from the ceiling of the little room. After breaking the suspensory thread with a knife and brushing the egg out, I placed it among the caterpillars in the bottom of the vial. Very few wasp's eggs could stand the rough handling which this egg received. The explanation of its endurance lies in the toughness of its shell. The larva hatched in two and one-half days, having shed a tough translucent shell which could safely be handled with a forceps. After fifteen hours the larva had attached itself to a writhing caterpillar and had grown perceptibly. . . .

The length of the egg stage of *O. arvensis* is about two and a half days; of the larval stage, four and a half days; of the pupal stage, eighteen days.

Another nest which I observed an *arvensis* store and close on August 14 I opened nearly a month later (September 9). I was expecting to see a wasp emerge by this time, and had placed a bottle over the entrance to receive it. I found in the nest no offspring of the wasp, but a red pupa of a fly and fourteen caterpillars, of which four had dried up, three were dead though in good condition, and seven were actually alive.

Three caterpillars lived forty-three days, one forty-six days, and one remained for fifty-eight days in a condition good enough to be added to any waspling's bill of fare.

A survey of these few facts would seem to indicate that while the suspension of the egg and the young larvæ is a desirable condition and increases their chances of successful development, yet it is not an essential condition, as Fabre contended. Nor is it essential, in consideration of the longevity of the paralyzed prey, that the caterpillars be devoured in the order in which they were stored.

Three Kansas Eumenidæ—*O. annulatus, O. geminus,* and *O. foraminatus*—were observed by Messrs. Hungerford and F. X. Williams[9] in northwestern Kansas, while on the Kansas University Biological Survey during the summer of 1910. *O. annulatus* is one of the species whose nesting habits I observed. I collected a number of specimens of *O. geminus,* but did not observe any of its nesting activities.

The excavation of two nests of *O. annulatus* was observed by the authors. These nests were burrows dug in open spaces in the prairie; over the burrow was constructed a short, almost vertical tube. The wasp moistened the earth, before digging, with water from a lagoon; in digging she employed her mouth parts and fore legs. Excavated earth was used in tube construction, and the rest carried off and dropped several feet away. "It is noteworthy," they write, "that *Odynerus* in disposing of the pellets of earth (which she does on the wing) does not cast them about indiscriminately, for it was observed that one wasp dropped them at a distance of from four to six

9. Ent. News, vol. 23, pp. 250-255.

feet from the nest; while the other disposed of hers at a distance of about three feet northwest of the burrow."

The nests were opened three days later. Both nests were one-celled. One tube was nine-sixteenths inch high; the other was one and one-thirtieth inches high. Its diameter was nearly one-fourth inch, inside measurement. In one case the tunnel was vertical for one and one-fourth inches, and from that depth curved in a westerly direction. The terminal cell was slightly greater in diameter than the gallery, and was horizontal. One cell contained an egg and two caterpillars; evidently provisioning had just begun. In the other cell were nine caterpillars and a small grub. The cell was closed with "a wad of packed soil one-fifth inch thick."

O. geminus is a burrowing wasp, but does not cover the entrance with a tube. A part, if not all, of the pellets are dropped within two or three inches of the hole. "The tunnels of *geminus,* which were often rather closely associated, were in barren soil or more or less sandy loam, with plenty of lagoons in the vicinity." These burrows included a number of cells, some as many as eight. The authors suggested that possibly *geminus* utilizes its holes for a second brood, for none of those examined would indicate that they were newly made. One nest contained refuse of old cocoons, one presumably of a parasite, another revealed three pupal cells of a muscoidean fly. The lepidopterous larvæ stored was probably *Pholisora catullus.*

In comparing the nest of the two species, *O. annulatus* and *O. geminus,* the authors suggest that the tube of the former protects the nest from attacks of insect parasites.

Several specimens of *O. foraminatus* were dug out of a decayed stump, which also sheltered a nest of *Crabro interruptus.* The brood was apparently just emerging. The cells of *foraminatus* were separated by mud partitions.

Monobia quadridens[10] nests in an old burrow of a carpenter bee (*Mylocopa virginica*). The sides of the burrow are renovated by a thin veneering of clay; then the burrow is filled with clay cells from the bottom upward. More than one wasp had been seen coming and going out of a single burrow. It preys on large cutworms. According to Comstock,[11] this species bores in solid wood.

10. Psyche, May, 1894, pp. 76-78.

11. A Manual for the Study of Insects, p. 660.

The Australian genus *Abispa*[12] constructs a nest with a funnel-shaped entrance and of so large a size that it might pass for the nest of a colony instead of a solitary wasp.

The females of *Rhynchium oculatum*,[12] according to Lichtenstein, construct from fifteen to twenty cells in pithy plants, and destroy from 150 to 200 caterpillars each. The East Indian *R. carnatium* uses hollow stems of bamboo. *R. nitidulum* constructs clay cells similar to those of *Eumenes*, and fixes them firmly to wood.

A number of observers have recorded food habits of various Eumenidæ. Riley[13] writes that the fraternal potter wasp, *Eumenes fraternus*, according to Harris, stores its cell with cankerworms. Its clay nests are always closely packed with eighteen to twenty worms. These nests are attached to goldenrod or other plants in the open, or they are cemented under loose bark of some trees. Sometimes they are even attached to leaves of deciduous trees.

E. B. Southwick[14] also writes regarding *Eumenes fraternus*, which is one of the worst enemies of the parsnip worm (*Depressaria heracliana*). He says: "One of these wasps would alight on the umbel in which a web was situated, and would begin to peer into it first at one end and then at another, all the time getting more and more excited. On discovering the worm within, it would commence to run its abdomen into the end of the web with its head toward the opposite end, as if trying to eject the occupant, and every now and then darting at the orifice as the worm would approach it. In this way it would work for a long time, first at one end and then at the other, no doubt each time thrusting out its sting." In this way the cell was packed at each end until it became too short to cover the larva. When it showed itself it was grabbed by the mandibles of the wasp and dragged forth with more or less difficulty. By repeated jerks and stings the larva was dislodged, then stung again and carried away by the wasp.

Nests were found on an old goldenrod stalk in an open wood. Four cells were all filled with larvæ, many of which were larvæ of the parsnip webworm.

M. J. Lichtenstein[15] writes of *O. crassicormis*. This wasp,

12. Cambridge, Nat. Hist., vol. VI, pp. 72-78.

13. Rep. U. S. Ent. Comm., III, p. 177.

14. Ins. Life, vol. V, p. 107.

15. Bull. Ent. Soc. Fr., vol. IV, p. 86.

he says, stores its nest with coleopterous larvæ of the genus *Phytonomus* (one of the Curculionidæ), either *P. variabilis* or *P. ruspiciosur*, which are common on Lucerne.

Marlatt[16] described the food habits of a small *Odynerus*. A small *Odynerus* was observed to examine the leaves of the black locust (*Robinia pseudacacia*). Some of these leaves were sewed together by the larva of *Pompelia gleditschiella*. The wasp eventually rested on the upper surface of one of these tied-together leaves; then ran to the under side and vigorously bit through the lower leaf. The hole was cut through in a few seconds. Then it grasped *Pompelia*, gave it a few turns with its mandibles, and flew away. Examination showed that the tree had been thoroughly worked over by *Odyneri*.

Schwarz[17] said that the cells of *Odynerus* which are in old burrows of *Anthrophora* around Washington are always stored with tortricid larvæ.

The Hawaiian species, according to Perkins,[18] prey on larvæ of the Pyralidæ, Noctuidæ, and Microlepidoptera.

Descriptions of Species.

There are nine species of the Eumenidæ upon whose nesting habits I have made observations. There are *Eumenes bolli, fraternus; Odynerus arvensis, annulatus, dorsalis, hildagi, papagorum, sulphuritinctus;* and *Pterochilus 5-faciatus*. I shall now give a table to distinguish these species, and detailed descriptions of them.

There is little claim for originality for these descriptions. For the most part I have compiled them from those prepared by De Saussure, Cresson, and Viereck. In some places I have quoted these authors directly, while in others I have paraphrased their descriptions, making some additions and subtractions.

The changes which I have made are mostly of minor importance. My chief aim in revising these descriptions at all is to give them more uniformity in regard to arrangement, terminology, and parts described, which would scarcely be possible in unaltered work of three different authors. Also, I wish the descriptions to conform to the Kansas varieties, and am endeavoring to make the former descriptions as brief as possible, for this paper is primarily biologic, not taxonomic.

16. Proc. Ent. Soc. Wash., vol. IV, pp. 172-173.

17. Proc. Ent. Soc. Wash., vol. IV, p. 173.

18. Fauna Hawaiiensis, vol. 1, pt. 1, p. 31.

The genera represented by the species discussed can be separated by the following table:

Anterior wing plicate in repose; middle tibiæ with a single terminal spur; tarsal claws unidentate ..... EUMENIDÆ
- A. Abdomen petiolate; labial palpi normal, four-articulate ..... *Eumenes*
- AA. Abdomen sessile or subsessile.
  - B. Labial palpi three-articulate, bipectinate, fringed with long hairs. *Pterochilus*
  - BB. Labial palpi four-articulate, normal ..... *Odynerus*

The following should separate the two species of *Eumenes:*

- A. Wasp, largely black ..... *fraternus*
- Wasp, largely yellow ferruginous ..... *bolli*

The following table should separate the species of *Odynerus:*

- A. First abdominal segment punctate dorsally.
  - B. Small wasps, 8 mm. long; a free yellow lateral spot on second abdominal segment ..... *papagorum*
  - BB. Medium-sized wasps, 13 mm. long; no free yellow lateral spot on second abdominal segment ..... *sulphuritinctus*
- AA. First abdominal segment not punctate dorsally.
  - B. Margin of second abdominal segment reflexed dorsally ..... *hildagi*
  - BB. Margin of second abdominal segment not reflexed dorsally.
    - C. Large species, 17 mm. long; clypeus finely punctate .... *dorsalis*
    - CC. Medium-sized species, 12 to 15 mm. long.
      - D. Largely black wasp; clypeus strigate punctate .. *arvensis*
      - DD. Largely ferruginous wasp; clypeus simply punctate. *annulatus*

O. arvensis Sauss.

O. arvensis Sauss.; Rev. de Zoöl. XX; 1869.
O. arvensis Sauss.; Syn. Am. Wasps Sol., pp. 270-272; 1870.

♀. Total length, 14 mm.; wing, 11 mm.
♂. Total length, 12 mm.; wing, 9 mm.

♀. A medium-sized, mostly black, coarsely punctured wasp. Clypeus widely pyriform strigate punctate; truncate at tip, one-toothed at sides of truncated margins. Thorax slightly widened in front; scutellum with low, indistinct medium carina; postscutellum transversely crenulate, the laterosuperior ridges blunted or effaced; the lateral edges of the hinder plate produced into a dentiform angle. The first abdominal segment smooth, truncate and a little rounded at the base; the second segment short, densely punctured, its posterior border offering a wide depressed zone, widened in the middle, very coarsely cribrose; the following segments similarly punctured. Insect black. Mandibles red; a spot at their base and a broad basal band in the clypeus yellow; inner border of orbits, a spot behind each eye and a spot on the front either yellow or reddish; scape of the antennæ red, with a black line above. Anterior border of the notum yellow, often followed with red; tegulæ yellow or red; postscutel and a spot on each side of the metathorax above, yellow; segments of the abdomen apically bordered with yellow, the first having its border on each side widened or confounded with a spot or oblique band, which is yellow surrounded with red, leaving above a black, square spot. Legs yellow, black at the base. Wings smoky or a little reddened, with a light violet reflection.

♂. Smaller. Clypeus polygonal, yellow, wider than long, truncate on its anterior border, offering a very small tooth on each extremity; its anterior portion a little prolonged, so that the polygon is not regular; hook of the antennæ black or ferruginous; mandibles and ornaments of the head yellow or orange; a red dot on the flanks before the tegulæ; often the posterior border of the prothorax red. Fifth abdominal segment often bordered with yellow.

Habitat: "The United States, particularly the south," writes De Saussure. He records specimens from New York, Illinois, Kansas, and Tennessee. Both Hartman and Cameron have recorded specimens taken in Texas.

O. annulatus Say.

A. annulatus Say; Long's Sec. Exp., Append. 29, II, 348.
Rhynchium annulatum Say; Bost. Journ. I (1837), 351, 4.
O. bairdi Sauss.; Revue Zoöl. X; 1858.
O. annulatus Sauss.; Syn. Am. Wasps Sol., 273-27; 1875.

♀. Total length, 12 mm.; wing, 10 mm.
♂. Total length, 10 mm.; wing, 8 mm.

♀. A medium-sized, rather slender, largely rufous wasp with coarse and dense punctures. This wasp closely resembles *O. arvensis* in form, from which it differs chiefly as follows: somewhat smaller and more slender; clypeus broadly pyriform but not as broad as that of *O. arvensis;* surface of clypeus simply punctate. Head rufous, except vertex, base of scape and flagellum, which are black; a spot on anterior portion of prothorax scutellum, a spot on scutum, tegulæ, yellow; rest of thorax rufous, except scutum and sides of mesothorax, which are black, and a spot below tegulæ, postscutellum, and a spot one each side on the metathorax above, and sometimes the anterior margin of the prothorax, part of the tegulæ and spots on the scutellum, which are yellow; usually there is a rufous spot in middle of scutum. Abdominal segments rufous, 1-5 bordered with yellow, the first having its border widened on each side, usually extending forward to the anterior margin of the segment; yellow maculæ on sides of second segment; often a black spot on the middle of the dorsum at the base of each segment. Legs rufous. Wings light smoky.

♂. Clypeus broader than high, more regularly octagonal; its anterior margin straight, having two distinct teeth on either side. Mandibles, clypeus, a triangle on the forehead, and a sinus of the eyes, a line on the scape, bright yellow; hook of the antennæ and postocular spots rufous. Otherwise as female.

This species is very variable in size and in coloration. I have specimens that measure 15 mm. in length. In coloration the Kansas forms vary particularly in the amount of black on the abdomen. In many specimens the black entirely replaces rufous on the third and following abdominal segments. De Saussure describes three varieties—a "black variety," a "rufous variety," and a "Mexican variety" in which yellow predominates. The Kansas forms are nearly like the "rufous variety."

Habitat: According to De Saussure, this species is found on the

prairies from Missouri to Texas, in New Mexico and the Mexican Cordilleras. In the Snow collections are also many specimens from Arizona and Kansas. Cameron reports specimens taken from Colorado.

O. dorsalis Fabricus.

Vespa dorsalis Fabr.; Syst. Ent., 367, 25; 1775.
Polistes dorsalis Fabr.; Syst. Piez., 273, 19.
Rhynchium balteatum Say; Bost. Jour. I (1837), 383, 1.
Monobia sylvatica Sauss.; Et Vespid. III, 168.
Rhynchium louisianum Sauss.; Et Vespid. I, 106, 7; 1852.
Rhynchium dorsale Sauss.; Et Vespid. III, 171.
O. dorsalis Sauss.; Syn. Am. Wasps Sol., 257-260; 1875.

♀. Total length, 17 mm.; wing, 14 mm.
♂. Total length, 15 mm.; wing, 12 mm.

♀. Large brownish wasp, ornamented with yellow. Clypeus a little wider than high, subpyriform; anterior margin truncate or even a little rounded, finely punctate. Head and thorax densely, strongly punctate; prothorax retracted anteriorly; postscutellum truncate, bearing a crenulation interrupted in the middle; metathorax rugose upon its borders, quite variable, according to specimens; its hinder plate flattened, striate, forming on each side a dentiform angle (at times blunted); its superior borders sometimes quite trenchant, sometimes effaced. Abdomen wide, conical; the first segment truncate apically, but rounded basally; the second finely punctured, offering along its posterior margin a wide rugose band, a little depressed, garnished with coarse punctures; this band a little widened in the middle; the very margin is smooth; the following segments are strongly punctured with the extreme margin smooth.

"Rufous Variety.—The whole insect rufoferruginous, except scape beneath, middle of prothorax, tegulæ, a line in the postscutellum, border of the first segment of the abdomen, yellow; feet mostly yellow; the flagellum of the antennæ black.

"Black Variety.—Insect black; mouth, clypeus, a spot behind each eye, articles one to three of the antennæ, rufous; prothorax, tegulæ, scutel, equally rufous"; yellow ornamentation as on rufous variety; "legs black; knees, tibia and tarsi yellow. Wings of a deep brown violet."

These two varieties are described by De Saussure, from whom I have taken the descriptions bodily. Both varieties and every gradation between them is found in western Kansas. The rufous variety is much the better represented of the two.

♂. Smaller. Clypeus as long as wide. Metathorax less blunted on the laterosuperior borders of the concavity, the superior edges more elevated, forming lines of salient rugosity, and separated from the postscutellum on each side by a fissure. Abdomen more conical; border of second abdominal segment deeply channeled and rugose. Clypeus, mandibles, inner borders of orbits, spot on the frons, a line on the scape of the antennæ, borders of abdominal segments 2-4, yellow. Wings not so deeply colored as in female. Otherwise marked as female.

Habitat: According to De Saussure, this species inhabits "the United States, especially the south." He records specimens from Pennsylvania, Illinois, Tennessee, Louisiana, South Carolina, and Mexico. In the Snow collections are specimens from Kansas and Texas.

O. hildagi Sauss.

O. hildagi Sauss.; Rev. et Mag. de Zoöl. IX, (1857), 275.
O. hildagi Sauss.; Syn. Am. Wasps Sol., 252-254; 1875.

♀. Total length, 13-14 mm.; wing, 10-11 mm.
♂. Total length, 11 mm.; wing, 8 mm.

A medium-sized, rufous, black and yellow wasp.

♀. The following description is taken directly from De Saussure, with two slight omissions: Clypeus punctured, widely truncate, its inferior part rather flattened and laterally bicarinate. Thorax in the form of an elongate square, not contracted posteriorly, densely and coarsely punctured. Postscutel sharply truncate, strongly crenulate. Metathorax very rough in its superior lateral face, its posterior concavity strigose, shining; margined with sharp edges, which form on each side a very strong dentiform angle, and which terminates superiorly in two eminences separated from the postscutel by deep fissures. Abdomen silky, quite conical, not ovate; its first segment large, as wide as the second, sharply truncate anteriorly, the margin of the second and following segments quite coarsely cribrose; the border of the second and third segments reflexed. Insect rufous and black and yellow, head black; mandibles, clypeus, margins of the orbits entirely or interrupted at the vertex, a spot on the forehead, and at the base of the antennæ rufous; mesonotum black; prothorax, scutellum, metathorax and tegulæ rufous; anterior margin of prothorax and a spot below the tegulæ refous or yellow. Abdomen rufous, all segments margined with yellow; the margin of the first segment widened at the base; triangular black spots at the base of the first and second segments; on second this spot is very large, sometimes covering half of the dorsal surface.

♂. Clypeus octagonal. Mandibles, orbits, a triangular spot on the forehead, a line on the scape of the antennæ, yellow. Margin of prothorax, scutel, a spot under the base of wing, and tibia, often yellow.

Habitat: De Saussure records species from New York, Louisiana, and Mexico. In the Snow collections are specimens from Kansas, New Mexico, and Arizona.

O. papagorum Vier.

O. papagorum Vier; Trans. Am. Ent. 88, 394-395; 1907.

♀. Total length, 9 mm.; wing, 7.5 mm.
♂. Total length, 8 mm.; wing, 7 mm.

A small black wasp, ornamented with yellow.

♀. Clypeus pyriform, terminated apically by a very small concave edge, rather coarsely punctured. Thorax elongate; metathorax narrowed; its concavity strigate-punctate; its superior lateral margins effaced by punctations. Abdomen ovate; the first segment subcampanulate, much narrower than second segment; cell segment punctate, most coarsely on borders. Black. The following yellow: edges of the clypeus except a break laterally on each side, a frontal spot, a mark immediately above the insertion of the antennæ, a mark in the emargination of the eyes, a postocular line, the anterior border of the pronotum, a spot below the tegulæ, a dot near the posterior margin of the scutum, postscutellum,

superior lateral edges of the concavity of the metathorax, posterior borders of all abdominal segments, and a spot on each side of the second abdominal segment. Wings subhyaline, deepened to fuscous in cells along anterior edge; interior and middle femora black, brown and luteous, posterior femora black and brown; tibia and tarsi reddish brown; middle and posterior tibia ornamented with a luteous strip on external aspect.

♂. Smaller. Clypeus polygonal, deeply emarginate anteriorly, finely punctured, a supraclypeal mark extending to posterior margin of the clypeus, and middle and posterior coxæ or a spot on those coxæ, yellow.

Types ♀ and ♂ in Snow collections. This museum possesses specimens from Kansas and Arizona.

O. sulfuritinctus Vier.

O. sulfuritinctus Vier; Trans. Am. Ent., 88, 389-390; 1907.

♀. Total length, 13 mm.; wing, 11.5 mm.

♂. Total length, 10 mm.; wing, 10 mm.

A medium-sized black wasp, much ornamented with yellow.

♀. Clypeus pyriform, longer than wide, anterior edge emarginate. Thorax elongate, narrowed behind; the concavity of the metathorax striate, its lateral margins forming on each side a dentiform angle. Abdomen ovate; first segment half as long as second; second segment reflexed. Entire body distinctly and densely punctate; punctures finest on first abdominal segment and base of second segment. Wasp covered with sparse golden pubescence. Black. Yellow confined as follows: a line on the basal half of the mandibles, clypeus excepting the margins of the anterior half and a triangular space in the middle, a spot between the insertion of the antennæ, the anterior aspect of the scape, a postocular spot; on the thorax a wide anterior border of the prothorax, portion of the tegulæ, a spot below the tegulæ, postscutellum, a spot on the superior lateral margins of the concavity of the metathorax; on the abdomen, all segments broadly bordered apically with yellow, this border continuing laterally, on the first and second segments, to basal margins of the segment. Coxæ and base of femora black; apical end of femora and tibia yellow; tarsi yellowish, with tendency toward brownish, especially in posterior pair. Wings brownish with yellow reflections.

♂. Smaller. Differs from female as follows: clypeus entirely yellow, no yellow marks in metathorax; yellow marks on anterior coxæ; tibia and tarsi more brownish than yellow.

Types ♀ and ♂ in Snow collections, University of Kansas.

Habitat: The museum possesses specimens from Kansas and Arizona.

Eumenes bolli Cress.

E. bolli Cress.; Hymenoptera Texana, Trans. Am. Ent., 4; 1872.

♀. Total length, 15 to 17 mm.; wing, 13 mm.

♂. Total length, 13 mm.; wing, 11 mm.

♀. Clypeus octagonal; the anterior side deeply emarginate, terminating on each side in two teeth, the parallel lateral sides with the anterior oblique sides forming dentiform angles; surface convex, finely punctured. A short but prominent carina between the antennæ. Head and thorax

coarsely punctured; posterior margin of scutellum convex. Petiole lengthened, pyriform; finely punctate; a medium furrow at apical end; second abdominal segment globose, densely punctate, with circular depression at the apical middle. Clothed with a short, dense yellow pubescence. Head black. Clypeus, labrum, a spot between the antennæ, a line in the emargination of the eyes, a postocular line, yellow; mandibles fulvous; antennæ with scape and two or three basal points of the flagellum rufofulvous; prothorax yellow ferruginous, more or less yellowish in front; mesothorax black, sometimes tinged laterally with ferruginous; scutellum ferruginous, black posteriorly; postscutellum yellow; metathorax yellow ferruginous, black on basal middle to apex; pleuræ ferruginous with anterior and posterior margins black; petiole ferruginous, basal half with a broad median black stripe, sometimes nearly as wide as the dorsum; second segment yellow, with a large blackish angular band, sometimes quite broad, starting from the basal middle and forking posteriorly at about the basal third, reaching the lateral margin at the apex; remaining segments ferruginous, tinged with yellow above. Legs yellow ferruginous; wings brownish with yellowish reflections.

♂. Smaller, less robust; clypeus narrower; third and following segments black, banded with yellow.

Habitat: Texas and Kansas.

Eumenes fraternus Say.

E. fraterna Say; Long's Sec. Exped., II, 344 (Append. 77); 1825.
E. fervens Sauss.; Vespides I, 40, 15; 1852.
E. mærops Sauss.; ibid. I, 41, 18 (var.?); 1852.
E. minuto Sauss.; ibid. I, 39, 14 (Syn. exclus.).
E. fraternus Sauss.; Syn. Am. Wasps Sol., 95-98; 1875.

♀. Total length, 17 mm.; wing, 12 mm.

♂. Total length, 13 mm.

♀. In form resembling *E. bolli.* Longer and more slender. Clypeus less deeply emarginate; petiole longer at second segment, more gradually globose, flat underneath, very convex above, finely punctured, its posterior border with double leaves. All the body covered with short gray pile. Insect shining black; two oblique spots on the basal margin of the clypeus, the carina between the antennæ, a postocular spot, a spot on the anterior aspect of the scape, anterior border of the prothorax, postscutellum, a spot under the tegulæ, a spot on each side of the postscutellum on the summit of the metathorax, apical margins of first and second and sometimes third and fourth abdominal segments, and a variable dot on each side of the second abdominal segment, creamy yellow. Legs black; tibia variable with creamy yellow; wings brownish with violet reflections.

♂. Clypeus deeply emarginate, narrower than that of female; entirely cream yellow or with black dot in middle; scape of antennæ marked with a yellow line; hook of antennæ ferruginous.

Habitat: "The eastern part of the United States," writes De Saussure. "Very common." De Saussure records specimens from Louisiana, South Carolina, New York, Tennessee, Wisconsin, Pennsylvania, Illinois,

and Connecticut. Ashmead records having found it in Florida, and Harris in Massachusetts. In the Snow collections of Kansas University all the specimens are from Kansas.

Pterochilus 5-faciatus Say.

Pt. 5-faciatus Say; Long's Exp. to Sources of the St. Pet. Riv., II, Supp. 70; 1824.
Rhynchium 5-faciatiam Say; Bost. Jour. I (1837), 385.
Pt. 5-faciatus Sauss.; Syn. Am. Wasps Sol., 371-372; 1875.

♀. Total length, 17 mm.; wing, 15 mm.
♂. Total length, 12 mm.; wing, 11 mm.

♀. Mandibles large, armed with four lobiform teeth besides apical point, their external sides strongly ciliated with long hair. Clypeus transverse, sparsely punctate; posteriorly convex; somewhat produced in the middle; anteriorly rapidly narrowing toward apex, which is deeply emarginate; points of emargination toothed. Whole body punctate; head and thorax densely so; basal halves of first and second abdominal segments finely and sparsely, punctations increasing in density and coarseness toward distal margins of the segments; pygidium densely punctate. Thorax globular. Abdomen ovate, subsessile; second segment with a transverse carina at the base. Apical segments of the abdomen, posterior edges of tibia, and tarsi covered with sparse light brown pubescence. Black; strikingly marked with ferruginous and yellow. Head black, except mandibles, clypeus, first and second joints of antennæ and a postocular spot, ferruginous. Thorax black, except prothorax, tegulæ, a spot on the anterior margin of the scutum, sides of metathorax, lateral margins of its concavity, and sometimes a spot below the tegulæ, ferruginous; two large spots on scutum, the postscutellum, and sometimes a spot under the tegulæ, yellow. All the abdominal segments broadly margined with yellow. First abdominal segment ferruginous, with a wide black line along the center of the dorsum; second segment black with large ferruginous spots, sometimes touching the anterior margin, on either side. The remaining segments black. Wings smoky. Coxæ sometimes black; otherwise the legs are ferruginous.

♂. Smaller. Clypeus hexagonal, seven-sided, the anterior side deeply notched; widest anteriorly; yellow. Anterior margin of prothorax, a spot below the tegulæ, and a postocular line, yellow. On the first abdominal segment there is a small yellow spot in the large furruginous spot on the sides.

Habitat: Kansas, Missouri, and Texas.

The Field of Observation.

The observation and collections upon which this paper is based were made, as I have previously stated, in twelve counties of northwestern Kansas, in connection with the Biological Survey of the University of Kansas. The survey was made under the direction of Prof. S. J. Hunter. Mr. Francis X.

Williams was the head of the expedition. The party consisted of four men, besides the chief, all graduate students in the department of entomology.

The purpose of the survey was to study insect distribution in the territory covered and to add to the Snow entomological collections in the Museum of Natural History at the University of Kansas. This plan necessitated that the major portion of the time should be spent in general collection. However, whenever a eumenid colony or a single nest was located, I was given all the time necessary to devote to the study of the wasp's activities. Many nests, which I would not have otherwise had opportunity to observe, were first located by Mr. Williams, who directed me to them. He also made many helpful suggestions regarding my observations and the method of conducting them. All the eumenids collected on the trip were placed in my charge, in order that I might have sufficient material for a systematic study of the group.

The counties covered by the survey are included by an almost square area, occupying the eastern half of the northwestern quarter of the state. About one week was spent in each county. Camp was pitched, generally in some central point near a stream, and from this center radiated the daily collecting trips. Eumenidæ was collected in every county but one—Barton.

The itinerary in detail was as follows: Barton county, June 19 to 25; camp near Great Bend, on the Arkansas river. Rush county, June 25 to July 2; camp near Rush Center, on Walnut creek. Ness county, July 2 to 9; camp near Ness City, on Walnut creek. Trego county, July 9 to 16; camp in southern part of county, on the Smoky Hill river. Ellis county, July 16 to 23; camp near Hays, on Big creek. Russell county, July 23 to 31; camp near Russell, on the Saline river. Osborne county, July 31 to August 6; camp near Osborne, on the south fork of the Solomon river. Rooks county, August 6 to 13; camp near Stockton, on the south fork of the Solomon river. Graham county, August 13 to 20; camp near Hill City, on the south fork of the Solomon river. Norton county, August 20 to 27; camp near Lenora, on the north fork of the Solomon river. Phillips county, August 27 to September 2; camp near Kirwin, on the north fork of the Solomon river. Smith county, September 2 to 6; camp near Smith Center, on Rock Island lake.

Most of the land on which we collected, except in the river bottoms, was rolling. In Trego, Russell and Rooks counties it was very hilly, with many prominent stone outcrops. Along the rivers in those counties were cliffs varying from 80 to 150 feet in height.

Except along watercourses and around dwellings, the country had little timber. Even in the former situation the timber was either sparse, or a narrow strip, sometimes 100 yards wide, along the stream. The amount of virgin soil varied in the different situations from 25 to 90 per cent.

The season was unusually humid for that part of Kansas. It rained at least once during every week but two while we were in the field.

Odynerus papagorum Viereck.

Edges of streams and pools and the sunny sides of high cliffs are the situations in which I found wasps of this species most easily. I first noticed them at a cattle crossing on a creek. Coming and going continuously, each wasp, no doubt, made many trips a day to that stream for its load of water. Some of this activity, I later found, was centered in home-building in the side of a clay bank. I also soon learned to find them hunting on the heads of the sunflower and gaillardia—the feeding ground of their caterpillar prey.

I collected wasps of this species in five counties, and found their nests in four of them. When in Ness county, from July 2 to July 9, these wasps were abundant, and the nesting season seemed to be at its height. Hundreds of them were at work there in the high banks of light earth. It was in that place that I gave the most time to observing this species. The first colonies found were near Rush Center, in the banks of Walnut creek, on June 28. In Ellis county, from July 16 to 23, and in Osborne county, from July 31 to August 6, I found a few old nests and took a few specimens, but no nest-building was in progress. A few specimens were also taken in Trego county, from July 7 to 16.

Along Walnut creek, near Ness City, in a bank rising about thirty feet above the water, was the favorite nesting site of *O. papagorum.* The lower half of the bank was sloping talus; the upper half was practically perpendicular. In this upper half the nests were excavated. Most of these were at least three feet above the talus, although occasionally I found nests

within a foot of it. I did not observe a single nest within four feet of the top of the cliff. Perhaps the deep roots of the prairie grass interfered with digging there. All of the colonies were situated along western or southwestern exposures. There were other cliffs facing north and east, apparently exactly like those facing west, but, I believe, without a single nest. A bank in which there was much clay seemed to be avoided, although I did find a few nests in very hard clay. I did not find a single one in banks that were shaded by trees.

In choosing a location on the face of the cliff many wasps seemed to prefer a partially sheltered place. Little earthen ledges which protruded an inch or more sheltered many entrances to burrows. A crevice or a hole in the face of the cliff often had one or two nests near its outer edge. Even in the sides of the deserted burrows of the large digger bee, *Anthrophora occidentalis,* some of these wasps excavated their homes.

Two colonies were located on Walnut creek, in Rush county. One colony with about twenty nests was in a sunny, west-fronting cliff along the creek. All the nests were below the sod root line. The cliff was similar in both appearance and in character of earth to the favored nesting site in Ness county, The other colony was located in an artificial bank at the entrance of a dugout cave near the creek. This colony was from three and a half to five feet above the ground, and the highest nests were two feet from the top of the bank.

In Osborne county only small colonies—the largest had only seven nests—were noted. This was in spite of the fact that the cliffs which furnished nesting sites were similar in appearance to those in Ness county. They differed from that favorite nesting site, in that the earth at Osborne was much more sandy. Also, as far as I observed, these banks were always shaded by trees, except on a few north exposures. It was in these unshaded places that I found the colonies.

In Ellis county I found the remains of an old colony—four tubes over empty burrows—in the sides of a pit. They were about two feet from the surface and were on the side facing east.

The home of *O. papagorum,* as previously stated, is excavated in the face of an earthen bank. Excavated larval cells are connected with each other and the outside world by a burrow. These cells do not always open directly into the burrow,

but are sometimes arranged in galleries, the lower cells opening into the upper. Over the entrance of this nest is built a fragile earthen tube, in diameter about one-eighth of an inch, the same as that of the burrow, and in length varying from one-fourth of an inch to two inches.

The number of cells to a nest, in those which I investigated, varied from one to fourteen. In Rush county, among eleven nests the average number of cells per nest was a fraction less than four. The largest number of cells to a single nest found there was eight. In Ness county the average number of cells per nest, among sixteen nests opened, was six. There I found one nest with fourteen cells and another with ten cells. There were no others with more than eight. At Osborne the average among the four nests excavated was three. Of all the nests excavated during the entire summer I found but three with only one cell.

In the larger nests the cells were invariably arranged in galleries. The average number of cells to a gallery was between two and three. Of all the nests that I opened I found but one gallery with four cells.

The burrow led into the bank either in a horizontal direction or pointing downward; it never pointed upward. At various distances from the entrance, from one-half inch to five inches, there were openings from the main burrow into cells or into branch burrows leading to cells.

There was little uniformity in the arrangement of the cells. Yet I have found a number of nests in which symmetry prevailed. This was the case in the largest nest that I found, one with fourteen cells. These were arranged in seven galleries of two cells each. The burrow terminated in one gallery. The other six galleries were arranged in pairs at intervals along the burrow. On the other hand, I found many nests in which all the cells came from the same side of the burrow. Still other nests had a varying number of cells to the gallery.

The size and shape of the cells was nearly uniform in all that I measured. They were barrel-shaped excavations five-sixteenths of an inch in diameter. The long axis of these cells generally pointed downward. In 20 per cent of the cells that I noted the long axes were nearer horizontal than vertical. In a few cases the long axis was actually horizontal.

The burrow and the entrances to the cells were about one-eighth of an inch in diameter. The burrow was just big enough

for the wasp to enter, but did not permit its turning around while in the nest. The length of the burrow varied greatly, from one-fourth of an inch to five inches. The average distance for the first entrances to cells to the opening into the burrow was one and three-sixteenths inches. In one case which I noted the burrow opened into the first cell within one-fourth of an inch of the outer entrance.

The earthen walls of the cells and burrows were packed and smooth. They were always harder than the surrounding earth, forming a layer distinct from it, due to the fact that water, and perhaps saliva, was applied to them.

Earthen tubes projecting from the face of a bank over the entrances of burrows attracted my attention to the first *Odynerus* colony that I ever observed. These tubes were small and fragile, being only about one-fourth of an inch in diameter, inside measurement. In length they varied from one-fourth of an inch to nearly two inches. Most of those over one-half inch in length curved downward at the distal end. In texture the tube appeared to be made of a network of earthen cords, which were laid close together longitudinally, and with enough wide crossbands to hold them together. I did not note a single tube in which the direction of the strands of network were much longer at the distal end of the tube than near the basal end. At the base the tube walls were solid or with only very small openings. The width of the spaces at the distal end of the tube was about the same as the width of the earthen cords.

In spite of the apparent fragility of these tubes, they were quite durable when exposed only to natural conditions. While they were so brittle that I had difficulty in removing them from the bank with a pair of tweezers without breaking them, yet rain and wind appeared to have little effect upon them. I have excavated nests in which all the cells were empty except for pupal skins, and over some of these burrows were tubes one and one-half inches long. They had been built at least a month before, probably much longer than that, and had been exposed to several rains. The rains left no record of the percentage of tubes they may have destroyed. The fact that the wasps often select sheltered spots as nesting sites indicates that the weather may affect the durability of the tube. Yet I believe that many of these tubes endure for longer than the nest has inhabitants, and far longer than their fragile appearance would warrant. This durability is due, I believe, as

Sharp suggests regarding *Eumenes,* to saliva or some other buccal secretion which the wasp may mix with the earth and water during the construction of the tube.

One purpose of this tube, as has been suggested by Messrs. Hungerford and Williams regarding the tube of *O. annultatus,* is to hinder parasites from finding the entrance to the burrow. I shall discuss this in my notes on parasites.

The very beginning of nest-building—that is, the location of the site—I observed but once, in Ness county. Here a wasp was walking rapidly back and forth on the face of the cliff, covering an area of a few square inches. Occasionally she would stop and test the surface with her mandibles. After two or three minutes of this surveying she took wing and zigzagged up and down a few inches in front of the area over which she had been running. She alighted, then repeated the uncertain flight in front of the cliff, and again alighted in the same place. Again she took wing, this time making a few large zigzag circles before the face of the cliff, and then flying away.

I had watched her performance with curiosity, but did not realize its importance until she had returned a minute later with water. She flew almost directly to the place she had so carefully surveyed, wet a spot, and began digging.

O. papagorum dug rapidly both with her mandibles and her fore feet, pulling the moist earth to the edge of the burrow, and there pressing it against the bank, making a thick foundation for the tube wall. While her head and fore legs were constantly at work within the burrow, the rest of her body also was in motion, swinging around the burrow entrance. At one instant the wasp was facing the lower side of the burrow; the next instant she might have changed her position so as to be facing the opposite way. The burrow was an axis about which the wasp's body swung back and forth.

Soon the tube became so long that it was impossible to pull the earth to its edge without backing out. Then Mrs. Wasp began to form the excavated earth into pellets, which she carried out in her mandibles to add to the length of the tube. She would then press the tip of her abdomen against the outside of the tube while she worked with her fore feet and mandibles within.

After she had been digging for three and one-half minutes she went for more water. This trip occupied forty seconds.

The next three successive trips for water were made at intervals of approximately four minutes each.

After fifteen minutes' work the wasp was completely hidden in the tube when digging. After fifty minutes the tube was one and one-fourth inches long, and near the tip it was curved downward. She then began discarding the excavated pellets, no longer using them to add to the tube. She would back out of the tube with the pellet in her mandibles, poise on wing a moment, just long enough to drop the pellet, then she would reenter at once. When she began dropping the pellets I supposed that the tube-building was finished. However, when I returned, within only two hours after the excavations had been started, the tube was two inches long. At this time it was finished, I believe.

I left her then, still dropping pellets. She had begun digging at 2:30 P. M. July 5. The next morning when I took my place before the cliff she was provisioning her nest with caterpillars. But the nest-building had not been completed, for in the afternoon of July 6 she was again excavating, probably adding more rooms to her house.

I have observed many of these wasps at work on their nests; a few of them I noted when the excavation began; and the routine of work—the method of digging, the building of the tube, the dropping of pellets, and the occasional trip for water—was essentially the same.

There was little regularity about when time should be spent on tube-building. The tube was always started at the beginning of the work. Often it was finished before any of the pellets of earth excavated from the burrow were thrown away. On the other hand, I have noted a number of instances in which the tube was scarcely more than started when building it further seemed to be abandoned; the excavated earth was discarded. After one or two cells had been dug and provisioned, work on the tube would again begin.

Earth used in tube-building, as I have stated previously, is usually excavated from the burrow. There are rare instances, however, in which this is not the case. I noted one wasp discard most of the earth taken from her burrow one afternoon. The next afternoon she laboriously collected particles of earth from the side of the bank several feet below her nest with which to lengthen her tube. I noted another wasp set about lengthening her tube after she had wasted much soft earth

excavated from her burrow. This wasp was less scrupulous than the one just mentioned, for she stole soft earth freshly excavated from its burrow from the tube of a neighbor—the digger bee, *Anthrophora occidentalis*. These cases, of course, are exceptional, for such poor economy is rare among the *Odyneri*.

When the nest has been provisioned its entrance is sealed with mud. There seems to be no rule as to exactly where it shall be. Of eight closed nests that I investigated in Rush county, three were sealed in the basal end of the tube at the entrance to the burrow; two others were only at the distal end; the remaining three were in two places, both at the distal and basal ends of the tube. Earth for closing the nest was generally taken from the cliff near the nest.

In all their excavations and masonary these wasps use water. Even when collecting earth from the sides of cliffs to close their tubes they make frequent visits to streams.

After the excavation of the nest it is provisioned with food for the wasp grub. In all the nests that I opened a noctuid caterpillar, apparently of the group Heliothinæ, was used. The largest of these caterpillars that I took from nests were 13 mm. in length. Some were as short as 10 mm. Their dorsal color was dark red or reddish purple, with four longitudinal white stripes. Ventrally they were greenish or purplish white. I found this caterpillar feeding on the heads of several species of sunflower (*Helianthus* sp.), the gaillardia (*Gaillardia lutea*), and the purple cone-flower (*Brauneria purpurea*).

The number of caterpillars stored in each cell varied from five to ten. The average per cell in Rush county was a little more than seven caterpillars; in Ness county the average was nearly nine. According to these estimates, the average number of caterpillars that should have been stored in an average-sized Rush county nest is thirty. The average number of caterpillars in an average Ness county nest should have been fifty-four. The largest nest that I found—one with fourteen cells—should, according to the Ness county average, have contained 126 caterpillars.

The largest number of caterpillars that I actually found in a single nest was fifty. This nest had eight cells. In two of these cells there were no caterpillars, for the wasp grubs within were full grown. In another cell there were seven caterpillars and a small wasp grub. In the other cells the

wasps had not hatched, and consequently the larder remained untouched. Three of these cells contained eight caterpillars each, one contained nine, and another ten. The nest undoubtedly at one time had contained at least fifteen or twenty more caterpillars than it did at the time when I opened it.

Why should the average number of caterpillars per cell have been so much higher in Ness county than in Rush county? There were two conditions that may have affected this difference. The caterpillar prey was much more abundant in Ness county; so were the wasps. A more important item is, that the cells opened in Ness county which I could consider in this count were stored on an average a week later than those that had been in the same condition in Rush county, for any cell that had been stored more than three days before we opened it was likely to have its larder more or less depleted by the hungry wasp grub. The weather had been considerably warmer while we were in Ness county, and the activity of the wasps was correspondingly increased. This may also have been one reason for the larger number of cells in the nests in Ness county.

I noted these wasps frequently on their hunting ground—containing the food plants of their caterpillar prey. But in spite of the comparative abundance of both the wasps and the caterpillars, I saw the capturing of prey only twice. On one occasion a wasp seized a caterpillar near the anal end, and by repeated jerks pulled it from its hiding place between the disk flowers in the gaillardia head. When the caterpillar finally let go both rolled from the flower to a leaf below. For an instant they were out of my sight. When I saw them again the wasp was holding the caterpillar by the neck and was stinging it under the thorax. I noted two thrusts. Then the wasp quickly bestrode its prey and began maxalation. Some movement of mine must have disturbed the wasp, for it stopped suddenly, watched me for a moment, and then flew away, leaving its victim on the leaf. The caterpillar appeared to be dead, and did not respond to any irritation. Unfortunately I did not keep it to observe further developments.

On another occasion I noted a wasp on a sunflower astride a caterpillar and maxalating it. Then she turned the caterpillar ventral side up and continued chewing and twisting its neck; then she flew away with it.

When hunting, this wasp sometimes runs quite rapidly over the flower heads. More often her progress is very slow, as she peers carefully among the disk flowers.

I was anxious to observe the wasp's attack upon her prey more closely, and thought to bring this about by artificial means. With nails I pinned two sunflower heads in the midst of a colony. Upon these sunflowers I placed about a dozen caterpillars upon which *O. papagorum* preyed. There were the same species of caterpillars for which the wasps had been searching so diligently in the field, within a few inches of the thresholds of the wasps' storehouses; but my efforts were fruitless. Not a caterpillar was attacked. Not only did the wasps ignore the caterpillars I had placed there for their convenience, but they seemed even to be wholly unmindful of the sunflowers. They flew directly to and from their nests as if nothing had been changed in the site of their colony.

The caterpillar is carried ventral side upward. With her mandibles the wasp grasps the caterpillar's neck. One pair of legs are also used in holding the caterpillar's body under her own.

Upon reaching her nest, the wasp with her mandibles and legs quickly moves the caterpillar, head first and ventral side upward, into the tube. Then she follows it in. As far as I have observed, the wasp always pushes the caterpillar with her head. After the caterpillar is stored she backs out and again goes on the hunt.

Storing caterpillars was not always an easy matter. On one occasion I saw a wasp have considerable difficulty in pushing a caterpillar ahead of her into the tube. The caterpillar did not seem to be thoroughly paralyzed, for as soon as it was pushed ahead of the wasp it would try to curl up or hold to the sides of the tube. After several attempts the wasp started it into the burrow. About four minutes later she backed out, bringing the unruly caterpillar with her. She alighted on the side of the cliff and vigorously bit its neck and first thoracic segment. After belaboring it for about a minute she pushed it in again, this time with no apparent trouble.

Of all the caterpillars that I took from cells, not one that I noticed was dead. Even those that had been in cells so long that nearly all of their partners had been devoured by the wasp grub still responded to stimulation. The caterpillars were paralyzed with varying degrees of success. Some would only

move their abdominal segments when irritated, while others could make their way out of the cell after it had been opened. One caterpillar that I had seen captured in the field was apparently dead or totally paralyzed. This was the only exception. It has since occurred to me that this state may have been only temporary. *O. papagorum* may totally paralyze caterpillars when she captures them, thus making them more easily managed during the storing process. After it is stored the caterpillar may partially recover from the paralysis.

Most of the cells freshly stored were packed with a tangled mass of caterpillars. Usually there was no vacant space in the cell.

On removing the mass of caterpillars from the cell I often found the egg suspended from the roof of the cell by a white thread. It was not suspended above the caterpillars. As far as I observed, it was always in the part of the cell farthest from the entrance to the burrow. Sometimes it was attached to the roof at the lower end of the burrow, so that the egg was nearly in the bottom of the cell. In spite of the thread attachment, in most cells the caterpillars must have been fairly piled upon the egg.

Oviposition may take place before any caterpillars, or after only a few, are stored. The usual position of the egg would indicate that it was deposited at least before many caterpillars were stored. I did not open a single empty cell in which I found an egg. However, I did find eggs suspended in only partially stored cells; in one case the cell had but two caterpillars.

The length of time required to make and store a nest depends chiefly upon the number of its cells, and upon the weather. In cold, damp weather the wasps are very sluggish and work but little. Wind also has a discouraging effect upon work. On hot, sunny days they were most active. I noted one three-celled nest that was finished in two days. On the other hand, I opened larger nests which contained larvæ and pupæ of ages that must have been at least ten days or two weeks apart. The length of time required for nest-building also depends to a certain extent upon the individual wasp, as some are much faster workers than others. It is also difficult to make an estimate of the length of time required to store a cell, as I have found wasps with as many as three cells open at one time and storing caterpillars in all of them.

An extract from my field notes may show about how fast an average wasp works on a favorable day. It reads as follows: "*O. papagorum* left nest at 8:40 A. M. Returned in eleven minutes with a caterpillar. Storing it required three minutes. Returned with second caterpillar in twenty minutes. Stored it in five minutes. Hunt for third caterpillar took twenty-five minutes. Spent eight and one-half minutes storing it. Returned in fifty-three and one-half minutes. Stored it in three minutes. Came out and backed into tube (perhaps to oviposit). Stayed inside five minutes. Returned with caterpillar in twenty-six minutes. Storing it required thirteen minutes." Thus three hours and forty-five minutes were spent in capturing and storing five caterpillars.

The egg of *O. papagorum* is cylindrical, slightly tapering toward the rounded ends. It is creamy white in color. The filament attachment is white and about the same length as the egg. The egg is 2½ mm. long and ⅔ mm. in its greatest diameter.

The larva is a very stout grub, much larger posteriorly than anteriorly. Its ventral outline is slightly curved, and when mature is about 10 mm. in length. Its dorsal outline is strongly curved and is 13½ mm. in length. Its greatest diameter is 4½ mm. In color the grub is whitish. The pupa is also whitish, and is 9 to 10 mm. in length.

Closely associated with *O. papagorum* was a cuckoo bee, *Chrysis pattoni.* The green parasitic bees were ubiquitous on the faces of cliffs in which the wasps nested. They often seemed more numerous than the wasps themselves.

These chrysidids spent most of their time searching the face of the cliffs, investigating every hole or crevice in the bank, and sometimes finding their way into the tube of *O. papagorum.* These same cliffs were also used as nesting sites for small andrenid bees. While I seldom saw a cuckoo bee pass one of these burrows by without stopping to look into it, I never saw one actually enter an andrenid nest. They seemed to be searching for the storehouse of *Odynerus.*

The tube over the entrance to the burrow was of considerable importance, I believe, in keeping these undesirable guests out of the nest. Because of this tube, cuckoo bees seemed at least to have great difficulty in finding their way into the burrow. When a cuckoo bee would come in contact with a tube it would generally pass it by, while it would easily have found an open

burrow. However, when it found the entrance to the tube it would go in at once, even though the wasp might happen to be within the nest. In the latter case the chrysidid would come out in great haste.

On one occasion I saw this *Chrysis pattoni* break open a tube with its mandibles. The tube had been sealed the day before by the wasp. *Chrysis* did not try to break the tube at the base, where it was thickest, but at the distal end. I took *Chrysis* out of the nest after it had penetrated to the main burrow.

O. papagorum occasionally showed signs of hostility toward the cuckoo bee by darting at it when the latter was too near its nest. The cuckoo bee always made good its escape. It also showed signs of fear when it entered the wasp's nest and found the owner at home. Most of the time, however, each of these insects ignored the other's presence.

In spite of the abundance of this cuckoo bee, I found little evidence of parasites in any of the nests that I opened. Pupal cases, probably of some chrysidid, were sometimes found in nests. I found one nest with an unfamiliar grub in it feeding in the same cell with the *Odynerus* grub.

Joint proprietors with *O. papagorum* of the cliffs in which the large colonies were located were *Anthrophora occidentalis*, several andrenid bees, several species of philanthids, *Trypoxylon* sp., and *O. hildagi*. No advantages or disadvantages to *O. papagorum* seemed to result from this proximity of other insects except of *Anthrophora*. Twice I noted *Odynerus* taking mud from this bee's tube, and the vacated burrows of the bee sometimes furnished shelters for the bases of the tubes of *Odynerus*. Had they been more numerous, *O. hildagi* might have become a rival for food, as they preyed on the same caterpillars.

This wasp was strongly colonial in habit. It may have been due to a certain extent to the scarcity of ideal nesting sites. This does not seem to me to be sufficient explanation, however. In Rush county a colony was located on an earthen wall at the entrance of a dugout cave. This wall presented an area of bout thirty-five square feet, artificially made smooth. It was in one plane and all parts were almost equally exposed to the weather, as there were no ledges of earth for the protection of tubes to prejudice the location of a colony in a certain place. Yet a colony of ten nests was located on a space seven by

twenty-one inches. The great colony in the cliffs in Ness county was made up of many small colonies of twenty to thirty nests, while spaces between these colonies, which offered situations for nesting of essentially the same character, were untenanted.

I could not observe any advantage gained by this colonial habit. However, the wasps must have been influenced by each other, for there was a tendency in a colony for all to do the same kind of work at the same time. When I saw one wasp bring a caterpillar to her nest I knew that the rest of the colony was probably also on a hunt. When I saw one wasp back out of her tube with a pellet of earth I expected to see others also, either excavating or otherwise engaged in nest-building.

The time of day also seemed to be a dividing factor in the kind of work *O. papagorum* would do. Mornings were generally spent hunting and storing caterpillars. Afternoons were generally given to nest-building.

O. papagorum began working between 7:30 and 8 A. M. during my stay in Ness county. She began hunting at once in earnest, in contrast to some other *Odyneri* who would work only in a desultory way until the morning was half gone. Late in the afternoon some of these wasps would quit working. Others I noted were still busy just before sunset. The night was spent in the nest.

During the busy season these wasps must make many trips a day for water. Their familiarity with water does not make them incautious about approaching it. Sometimes they will alight upon still water, in tanks, pools, or in tracks beside streams, but I have never seen them alight upon running water, or even float upon it. When taking water from streams they alight at the water's edge. Often they will take water from the wet sand at the edge of a stream.

When *O. papagorum* alights on water or on the side of a cliff, or when hunting on a flower head, it always keeps its wings spread and held up obliquely from the thorax, thus constantly keeping them in a position to take flight at any time. This is characteristic of all the *Odyneri* that I have observed.

On their homecomings these wasps always, if undisturbed, flew directly to their tubes, paying no attention to the tubes of others in the colony. Was this due to a sense of direction or to a memory of the nest's surroundings? I had noted a wasp

making a zigzag flight before a small area in the face of the cliff in which she located her nest. This zizgzag flight I had supposed was a "locality study," to aid the wasp in finding the exact spot again. This idea I owed to a suggestion from the Peckhams; I considered it analogous to the many locality studies they had observed.

When I pinned two sunflower heads on the face of the cliff in the midst of a colony, as I have previously described, and the wasps absolutely ignored these decorations, my confidence in their observational ability was shaken. The wasps flew directly to their tubes as if there had been no change in the appearance of the side of the colony.

That afternoon I purposely knocked off two long tubes when the owners of the nests were away. When the wasps returned they flew without the slightest hesitation directly into their uncovered burrows. I went to another colony and paritally mutilated three other nests by knocking off the tubes and cutting out a part of the burrow, and then with my knife I made gashes in the bank for several inches around the entrances of these nests. Two of the wasps flew directly to their burrows and entered as usual. The other wasp lit a few inches at the side of the burrow, hesitated a moment, and then walked directly into it. When observing these wasps they seldom seemed to resent my presence. Usually they did not appear to notice me at all.

These wasps whose homes I had mutilated were not blindly unaware of the change. At the time I broke the tubes the wasps were enlarging their respective burrows. Apparently the tubes were finished. But within ten minutes after I had broken the tubes all of the wasps were building new ones. Only one of them began work on the new tube at once; all of the others continued discarding their excavated pellets for several minutes. All three of the wasps whose nests I had mutilated with my knife inspected by depredations several times before beginning the rebuilding of the tube.

The effect of a strong wind upon the work of these wasps I had opportunity to observe on the afternoon of July 4. A gale was blowing furiously from the southwest, striking diagonally the face of the cliff in which the *Odynerus* colonies were located. The temperature was high, as usual, and ordinarily I would have expected to see the colonies very active.

For two hours I stationed myself in front of a small colony of eight burrows. During that time I saw five of the owners of these burrows.

The first wasp came from the field unburdened, and entered its tube. In two minutes it came out and backed in. It stayed in this position for forty-three minutes, although three times it showed its head at the entrance of the tube. At last it came out, but reëntered at once head first. Eight minutes later it again came out and backed into the nest. The rest of the time I was there it occasionally showed its head at the entrance of the tube, but never ventured out.

The second wasp came home with a caterpillar. She had difficulty in alighting, for several times as she poised to grasp the tube with her feet the wind would dash her against the cliff. When at last she was successful in alighting she had difficulty in pushing the caterpillar ahead of her. Ten minutes later she came out of the tube and backed in. Twice after that she showed herself at the entrance, in thirty-seven minutes after she had backed into the tube, and again ten minutes later.

Wasp number three stayed at home all afternoon. Once she showed her head at the entrance.

The fourth wasp was excavating when I arrived. She would drop a pellet about every thirty seconds. After bringing out six or seven pellets she would go for water and battle with the wind on her return. Only twice she made the trip without mishap. Usually when she was about to alight the wind would dash her against the cliff, sometimes apparently causing her to lose her load of water, for she would again fly to the creek. After working in this way for thirty-five minutes she backed into her tube to stay, although she showed herself at least two times.

The fifth wasp tried to work the whole afternoon in spite of the gale. For some reason she was collecting earth from the side of the cliff and carrying it into her nest a few feet away, perhaps to seal some cells. She was very unsuccessful in her work, for nearly every time she would try to alight on the end of her tube she would lose her poise, be blown against the cliff, and would drop her load of earth. She would then go back for another. When I first noted her she would gather a load of earth in her mandibles and fly to the tube, approxi-

mately every fifty seconds. Later in the afternoon she was much slower. She was collecting earth when I first observed her, and made seven attempts before she succeeded in alighting with her load. She backed out part way in seven minutes, then disappeared again. Five minutes later she came out and started for a second load of earth. In four minutes she succeeded in alighting with a load. She came out and backed in. Six minutes later she again began work. It was fifteen minutes before she succeeded in landing. She remained in the nest only four minutes. The next successful trip required twenty minutes of struggle. When I left she was still battling with the wind.

Odynerus arvensis Saussure.

Odynerus arvensis is one of the most numerous of the eumenids in western Kansas. I collected it in every county covered by the survey, except the first one. It was common throughout the summer, being taken regularly between June 26 and September 6. It was most readily found in lowland fields and pastures or near water.

Along the edges of streams, throughout the entire summer, this wasp was by far the most conspicuous of the *Odyneri*. At crossings for live stock on streams, at the edges of sand or mud bars, where the insect can walk directly to the water's edge, I always expected to find an assemblage of these wasps. Where the approach to water in a stream was in any way abrupt I never found them; like *O. papagorum, O. arvensis* never floats on running water. However, they were common floating on water in cattle tracks at crossings or in small pools. At these situations wasps were constantly coming and going. They were the busy females getting water for nest-building.

On sandy beaches along watercourses I sometimes observed dozens of wasps, also of this species, apparently playing in the sunshine. In contrast to those just described, they seemed to have no particular business except to chase each other up and down the beach. They were very wary and active, like sand robber flies, and were hard to take with a net. I collected fourteen of these idlers one afternoon in Rooks county, and without exception they proved to be males. They could not have been waiting there for females to come for water, for nowhere along that sandy beach was there a place frequented

by females. I believe that males wait for females at the entrance of burrows when the latter are about to emerge. At any rate, one was brought to me by Mr. Mallory which he had taken waiting at the entrance of a burrow in which was a female almost ready to come out.

Both males and females of this species were frequent in lowland fields and pastures, but I seldom saw one on a hillside. In some places they were common on lamb's-quarter and croton plants. The former was the food plant of one of its caterpillar prey. The latter also may have been frequented for the same reason, but quite often I saw this wasp on the croton flower, apparently seeking nectar.

O. arvensis does not have the colonial nesting habit, nor does it favor one nesting site to the exclusion of all others, as does *O. papagorum.* Consequently its nests were less easily found and its habits not so readily studied.

O. arvensis, as I found her, was always a burrowing wasp. Her burrows were the least carefully made of the digging Eumenidæ that came under my observation. The variation that may occur in the nesting habits of a single species of wasp is here shown. This same species, when observed by Mr. Hartman in Texas, made her domicile in any convenient crevice in a wall or fence post.

An open space near water seemed to be the only characteristic common to all the nesting sites I observed. During the summer I noted eighteen nests in the course of construction or finished. Of these six were located in the talus at the base of cliffs along the edge of streams, two in moist flats within a few feet of the water's edge, five were in cow paths in pastures, three in open spaces in pastures, one in an open space in fallow land, and one other in the dry bed of an intermittent stream. One of these burrows opened in a short growth of grass, while the others were in spaces practically free from grass or weeds. One was located in a cow path running through a narrow strip of timber, while all the others were in sunny places. All the nests were within thirty yards of water but one, which was about a hundred yards from water. The character of the soil in which the nest was located seemed to be a matter of no consequence. There was every gradation from a hard clay mixed with limestone—so hard that I could scarcely dig into it with my knife—to the soft alluvial soil of the flats beside the streams.

Observations on nesting habits were made at intervals throughout the summer. Nests were noted in Rush and Ness counties; from July 16 to July 30 nests were found. None were found in the next three counties, but in the last three visited—Norton, Phillips, and Smith—from August 20 to September 6, nests were again located. Females were as numerous at a pool near Smith Center, September 3, as they had been at any place visited previously, indicating that the nesting season was still in full progress at that time.

The general direction of the digging of *O. arvensis*, whether she is working in level ground or in talus, is downward, and not horizontal like *O. papagorum*. At the bottom of her more or less vertical burrow are the larval cells. Over the entrance of the burrow is built a thick upright earthen tube.

Of all the nests that I observed, in only eight had the burrow been excavated as far as the brood cell when I opened it. Of these only two were entirely finished before I interrupted the process. These burrows ranged from three and one-half to seven inches deep. The average was five and one-fourth inches. The average diameter of the burrow was one-fourth of an inch. This long burrow was never absolutely straight.

The number of larval cells to a nest varies greatly. In six instances I found only one cell to the nest; in another instance I found three cells; in still another instance I found six cells.

Of those nests in which I found but one cell, only one burrow had been sealed by the wasp. Most of the others were still being stored with caterpillars, and might have had other cells added later. In two of these nests the cell was directly at the bottom of the burrow; in the other four the burrow made a sharp turn before entering the larval cell. All of these nests were situated in soil comparatively easy to dig in.

The nest with six cells was excavated in the hard clay talus at the base of cliffs along the Saline river. The cells were arranged in three galleries, two in each gallery, one cell being directly above the other. When I opened the nest five cells were closed and one was empty, serving as a hiding place for the mother wasp. The other nest consisted of three cells arranged one above the other. It too was in the clay talus. It was located by Mr. Mallory.

All but two of the cells in these nests were shaped like short cylinders with somewhat rounded ends. The diameter of these cells averaged one-half inch, and the length ranged from nine-

sixteenths to five-eighths of an inch. In two cases the cells were lengthened and the ends rounded to such an extent that they had the shape of ellipsoids.

The cells and burrows of *O. arvensis* were roughly excavated. The walls were packed a little, but are not always smooth as in the case of *O. papagorum.* They never formed a layer of earth around the nest distinct from the surrounding earth.

The tube which *O. arvensis* built over its nest was an erect, or bent, cylindrical, earthen chimney. In length it varied from one to one and one-fourth inches. The interior diameter of the tube at its base is about the same as that of the burrow, one-fourth of an inch. As the wall decreases in thickness toward the terminal end of the tube, these inside measurements of the tube grow larger. The tube has a substantial appearance. At the base the walls are about one-eighth of an inch in thickness. The tube wall is solid, not a network as the tube of *O. papagorum.* Its exterior has a granular appearance. The shorter tubes are generally straight, while the larger ones are bent.

In spite of its solid appearance, this tube is only a temporary structure. A light rain will dissolve it. If it escapes the rain, Mrs. Wasp tears it down when the nest is finished and stuffs it into the burrow. Thus the burrow, which could easily be betrayed by the large tube, is quite securely hidden. The tube is probably a temporary defense against parasites while the provisioning of the nest is in progress.

The nest-building I observed on five occasions, and in its very beginning twice. In a dry bed of an intermittent stream in Russell county, I noted a black *Odynerus* make a "locality study"—a few irregular circles over an area about eighteen inches in diameter—and then fly away. In less than two minutes she was digging in a spot over which she had been flying. She had moistened the spot and was working with her fore feet and mandibles. The excavated earth was used in tube-building. She worked much as did *O. papagorum,* putting the freshly excavated earth in place with her mandibles, then working with her mandibles and fore feet inside the tube, while the tip of her abdomen pressed against the outer wall. After the earth was in place she would quickly run down the burrow again for another load. Every three minutes, as regularly as if she had timed herself by a clock, she went to the

river for water. This trip took from one minute and forty seconds to two minutes. After the tube was half an inch high she began dropping pellets a few inches from the burrow.

I had watched her from 7:50 A. M. until 8:20 A. M. As I had other work for the morning, I left her. When I returned about noon she had deserted the nest. This observation was made July 24. The building of this nest was fairly typical, as far as I observed, of the nest-building of the species.

When the nest is stored the cells are sealed, the tube is torn down with the aid of several loads of water, and is tamped into the burrow. Loose earth around the burrow is also pushed into it until it is entirely filled. This process I observed but once.

Four species of caterpillars—three pyralids and one noctuid—were found in the nests of *O. arvensis* that I opened. I did not find more than a single species of caterpillar stored in one nest, or even taken in one locality. On the other hand, with each change of locality there was a change in the caterpillar prey. One of the caterpillars upon which this wasp preys, *Loxostege sticticalis,* is of considerable economic importance.

The caterpillars in every instance were alive in the nest when I opened it. *O. arvensis* was often very careless about the state of mobility in which she left her prey. Once several caterpillars actually climbed the sides of the glass vial in which I had collected them, worked their way through the cotton stopper, and were crawling actively about on the inside of my collecting bag.

All of the caterpillars which this wasp collected were rather slender. All were larger than the wasp, varying from 16 to 18 mm. I never found more than seven caterpillars in a cell.

A black *Odynerus* storing caterpillars in her nest I observed in Norton county, August 22. Mr. Williams had found this wasp's tube in a small open space on a fallow hillside, and called me to see it. I waited twenty-five minutes before the owner of the nest appeared with a caterpillar. She deposited it quickly, backed out of the nest, and again went to the field. In thirty-five minutes she returned with a second caterpillar. I then interrupted the proceedings by taking the wasp and opening the nest.

Her manner of entering the nest with the caterpillar differed somewhat from any of the others of this genus that I have observed. She flew to the tube and rushed into it at once,

dragging the caterpillar under her body, not stopping to push it ahead of her. Her method of carrying the caterpillar, its ventral side up, the wasp's mandibles grasping the caterpillar's neck, is similar to that of others of this genus. This was the only time that I observed the storing of caterpillars.

In this cell I found three very lively caterpillars. I also found an egg suspended from the cell roof, as far as possible from the entrance. Although this egg was suspended, it was hanging, not above the caterpillars, but among them. Had two or three more caterpillars been added they would have been piled above the egg. I assumed that in this case oviposition had taken place before the storing of the cell had begun. At least I had seen two of the three caterpillars stored, and oviposition had not taken place while I was there. I found the egg of this wasp on one other occasion. It was suspended from the roof of the cell as far as possible from the entrance. I had not seen the egg until several caterpillars had been removed, but the cell was so full that it must have hung among them. This cell had been fully stored before I found it.

This wasp may not always be active from the time her nest is begun until it is finished. The wasp with the celled nest, previously described, gave no sign of industry during the time I waited before her nest, which extended at intervals through three days. She visited the nest occasionally, but brought no load. On one occasion she started, apparently, to enlarge her nest, bringing out three pellets in one minute and forty seconds. After dropping the third pellet she flew away. When I opened the nest I found the wasp with her head in the entrance of the one empty unsealed cell.

The five closed cells were completely ravaged by a little brown ant (*Solinopsis* sp.). A few caterpillars' skins were left in one of the cells, but the others were empty except for the ants. This is the only suggestion of an insect foe of *O. arvensis* that I noted except a cuckoo bee that I dug out of a nest in Ness county. I was unable to take it, and so can not give the species.

As far as I observed, *O. arvensis* never had any trouble finding her way to her nest. She never seemed to be sensitive to observation.

Odynerus annulatus Say.

I found no general rendezvous for the workers of this species. This wasp is never found, unlike *O. arvensis* and *O. papagorum*, coming and going in considerable numbers for water to a particular mud bar or cattle crossing in a stream. *O. annulatus* is not usually cautious about approaching running water. Many times I have seen her alight fearlessly on a river roughened by the wind, and ride over a riffle without mishap. She can take water at almost any place along a stream. Why should she need a special watering place?

The males of this species, however, like the males of *O. arvensis*, do assemble for a dance in the sunshine. I noted this but once. On the west side of a stone outcrop, about fifty yards east of a small creek, was a long sand bank. Up and down this sand bank played a number of male wasps of this species. I collected six of them. This observation was made August 15, in Graham county.

This wasp was taken in all of the counties covered by the survey in which eumenids were collected. It was less numerous than *O. arvensis* and *O. dorsalis*. It appeared in greatest numbers in Trego and Graham counties, both in the western tier of counties covered. These counties, in the vicinity of our camps, were more nearly treeless than any others visited.

The variation of this wasp in nesting habits are as striking as its variations in color pattern. Sometimes she is a digger wasp, with a burrow and tube much like that of *O. arvensis*. Messrs. Hungerford and Williams described her as a builder of one-celled nests in open spaces in a prairie. I have found but three nests. One had three cells; it was dug through a sod, in an alluvial flood plain of a stream. Another had twenty-two cells; it was dug in a barren, hard clay talus at the base of a cliff. The third nest had been used previously by *Pelopeus* sp., and was appropriated by a lazy or economical member of this species. Because of the entirely different conditions connected with each of these nests I shall deal with each separately.

The wasp that used the old nest of *Pelopeus* I collected in Trego county, July 12. About 100 yards from the Smoky Hill river, near our camp, were chalk rock cliffs 110 feet high above the flood plain. In cavities of these rocks and under ledges were many nests of *Pelopeus*. While climbing among these rocks I saw a eumenid, which proved to be *O. annulatus*, carry-

ing a caterpillar into one of these nests. I could not climb up to the place, so I took the nest, wasp and all, in my net. She had stored five caterpillars in one cell. All the caterpillars were *Loxostege sticticalis.*

At the base of the cliffs in Ness county, in which this great colony of *O. papagorum* was located, was a narrow alluvial flood plain, which was matted with a variety of sedges and grasses. In the midst of this tangle of vegetation *O. annulatus* excavated a nest.

My attention was first attracted to this nest on the afternoon of July 4, about five o'clock. The wasp had evidently not been at work long, for the tube she was building was only about one-third of an inch high. I watched her for nearly an hour. During that time she made fifty-one trips into the burrow to remove earth. Ordinarily one of these trips was made in thirty seconds, though occasionally more time was required; two required over a minute each. She also made ten trips for water. She did not fly directly to the creek for water, as did all the others of this species that I observed, but went downstream to a sand bar. In most of these instances she would return to the nest in forty seconds, but would not always alight. She seemed greatly disturbed by my presence, although I would always lie prostrate on the grass when she went for water. Several times on her return from the creek she would fly away again without alighting, and would return several minutes later, hoping, no doubt, that I would be gone. One time she was gone eight minutes. She was also bothered by the wind, which had nearly stopped the activities of the colony of *O. papagorum* earlier in the afternoon. She would always alight on the grass above the entrance of her burrow, and seemed to do so with considerable difficulty. Before alighting she would always make a number of horizontal ellipses in the air above her nesting site. Perhaps these flights above the nesting site were to locate the exact position of the burrow.

This wasp worked much as did *O. arvensis.* She always backed out of her burrow with the pellet of earth, and applied it to the chimney with her mandibles and fore feet. Shortly before I left she began dropping pellets in a pile about three inches from the nest.

The next afternoon I returned to watch this wasp. She left the nest soon after I arrived, and returned in one hour and twenty minutes with a caterpillar. She spent five

minutes in the nest, and in fifty-seven minutes she brought another caterpillar. Like others of this genus, she carried it head foremost, ventral side up, grasping it with her mandibles and one pair of legs. She entered the tube dragging the caterpillar under her body.

The next afternoon I found her digging again. I took her for identification and opened the nest. The height of the tube was a little over one-half inch and its diameter was one-fourth inch. The tube was but slightly bent. Its walls were three-sixteenths of an inch thick, and their exterior surface was coarsely granular, like that of *O. arvensis*.

The burrow was nearly perpendicular. Including the cells, its depth was three inches. There were three cells, two in one gallery, which were stored and sealed up, and a single cell which was being excavated at the time I took the wasp. The cells were nearly globular and were one-half inch in diameter. Those that were stored were closed with thin mud caps. The walls of the burrow and the cells were packed, but did not form a layer of earth distinct from that surrounding them.

The two closed cells were stored with caterpillars, four and six respectively. Neither cell was packed. The caterpillar used was a naked green noctuid with three rows of dots on its sides. It averaged 15 mm. in length. I did not find the egg.

The third wasp of this species whose nesting activities I observed worked in the hard clay talus on a cliff, by the Saline river. She was an unusually large wasp for this species. The nest was first found by Mr. Williams, July 24. He marked the place and showed it to me that afternoon.

The burrow opened under a small flat stone—rather a flat pebble—which formed a protective ledge. From the entrance of the burrow, under the stone, the wasp built a horizontal tube similar in texture to the tube of the nest previously described. It was about one-third of an inch long. The clay in which the nest was excavated was very hard, so that I could scarcely dig in it with my digging knife.

The wasp was carrying out pellets when I first saw her. She would back out of the burrow, fly four or five feet and drop the pellet, and then return directly to work. Each excavation of a pellet required from two minutes and ten seconds to two minutes and thirty seconds. After every third

trip, usually—sometimes after every fourth—she would go for water. This required twelve to fifteen seconds. She would fly directly to the river below and alight on the agitated water. Sometimes she remained on the water for as short a period as six seconds. She continued to work in this way for an hour and forty minutes, and then flew away. In twenty-five minutes she returned to work, and was still there when I left.

At different times during the afternoon the wasp had manifested marked uneasiness because of my presence. If I crawled within eight or ten feet of the burrow she would invariably see me when she same out to drop a pellet, and then she would not continue work until I had withdrawn several feet. She never offered to fly away, as did the wasp previously mentioned. She showed her uneasiness by keeping up a zigzag flight about the nesting site, usually between me and the burrow. As soon as I would retire she would return to work.

The next afernoon I found her digging again. I caught her for identification and opened the nest. Opening the nest was a tedious task. Careful digging was very slow. I had expected to find a nest about three inches deep and with not more than four cells. In spite of that hard clay, this nest was seven and one-half inches deep and had twenty-two cells! What industry! What a Herculean labor for a wasp! And her work had not been finished.

The cells were arranged in five main galleries; some of these had small branches. The galleries diverged obliquely in different directions from the burrow, outlining a sort of a cone in the talus. The first division of the burrow into galleries was three inches below the entrance. The diameter of the burrow was one-fourth inch.

The cells were like ellipsoids. The diensions of an average cell were nine-sixteenths by seven-sixteenths of an inch. The largest number of cells in a single gallery was six. The walls of the cells and of the burrow were very smooth, almost forming a layer of earth distinct from the surrounding talus.

The nest had been in the course of construction so long that a part of the brood had already emerged. Eight cells contained only pupal exuviæ. Nine cells contained pupæ in various stages of development, one of which emerged the next day in a glass vial. Four cells contained grubs, three of which were evidently mature. In one cell with the other grub were

parts of two greenish caterpillars. Judging from the length of time it took others of this genus to develop, it had probably been stored not more than a week or ten days previously. There were no freshly stored cells. One cell contained twelve cast-off pupal cases of some small dipteron. This is the only indication that I found of interference with the activities of this wasp by another insect.

The larvæ and pupæ of *O. annulatus* were like the larvæ and pupæ of *O. papagorum*, only larger. The mature larva was 15 mm. long and very stout, being 7 mm. in width at the widest part. The pupæ were about 13 mm. long.

The capturing and subduing of the caterpillar prey by this species I observed but twice. In both instances the caterpillar was *Loxostege sticticalis*. The first caterpillar was taken on Russian thistle and the second on alfalfa. These observations were made in Trego county on July 12 and 13.

In the first instance the wasp spent five minutes dislodging the caterpillar from its nest. At last she seized the caterpillar by its anal end and deliberately dragged it backward over the thistle stem for several inches, until they both fell to the ground. The wasp then quickly grasped the caterpillar's neck, stung it three times under the thorax, and began maxalation. This process continued for four and one-half minutes. The wasp often rested, cleaning its abdomen and antennæ with its legs. When she started to fly I caught her.

In the other instance the wasp worked much more rapidly. She tore open the caterpillar's web, grasped it by the anal end, and they both dropped to the ground. The wasp quickly seized the caterpillar's neck and stung it three times under the thorax. She then maxalated the caterpillar and started to drag it away. After she had dragged it about five yards she took wing, circled high in the air, and disappeared. The entire process had taken two minutes.

O. annulatus was common hunting on the Russian thistle and alfalfa in Trego county.

Odynerus dorsalis Fabricus.

This large brown wasp was common in eleven of the twelve counties covered by the survey, being collected regularly between June 26 and September 6. I have collected this wasp as late as September 25 in Douglas county, on the State University campus. Like *O. arvensis*, it was most readily found in lowland pastures or by streams.

O. dorsalis, as I found her, was a burrowing wasp. I did not know that she ever built cells above ground until I read Mr. Hartman's paper. Usually she preferred to make her home in an open spot in a lowland pasture, in a path or in a well-traveled road. These nests were never found in sod, although sometimes a few blades of grass might be found in the space in which the nest was located. Even the vegetation around the space was always short, except in one instance. This exceptional nest I found in a stony knoll. The small space in which the nest was located was surrounded by a tall growth of mesquite grass (*Bouteloua oligostachya*). The soil in which the nests were excavated was always firm. The nest was always a vertical or nearly vertical burrow, at the bottom of which were one or two cells. No tube was built over the entrance. This situation was the usual one.

A variation from this form of burrow I found in the face of a vertical earthen bank of the Saline river. I found there a colony of eight nests, whose burrows led obliquely or horizontally for one or two inches into the bank, and then downward. The number of cells to each nest varied from three to seven.

The two types of excavated nests present a contrast to the earthen cells of the Texan *dorsalis,* built under a tuft of grass, which are described by Mr. Hartman.

The nesting season of *O. dorsalis* was at its height in the month of August. A wasp carrying a caterpillar was brought to me, July 24, by Mr. Williams. This was the earliest indication of nesting activities that came to my notice. In Osborne county, on August 4 and 5, the excavating and storing of seven nests were observed. At our next camp, in Rooks county, from August 6 to 13, four nests came under my observation. In Graham county, from August 13 to 20, I counted thirty-six nests either being built or stored. I might have found many more, but they were so common I did not hunt for them. In Norton county, from August 20 to 27, I believe they were no less numerous, but I took no count. There was a decided decrease in this line of activity in the next county, Phillips, where we were from August 27 to September 2. I found but two nests there. None was found after that.

The dates including the period of nesting activities of *O. dorsalis* may indicate the nesting period of only one generation. The colony located July 29, in the bank of the Saline

river, was mature. When I found it some of the wasps were emerging from their larval cells. I had no way of telling whether these nests were excavated earlier in the year, or whether they had been built the year before and the emerging wasps had wintered there. Throughout the month of July I had found *O. dorsalis* quite common about the watering places, but found no sign of nest building.

The nests of *O. dorsalis* found along roads or in open spaces in pastures, were, as I have stated, burrows, vertical or nearly so, at the bottom of which the larval cells were located, one above the other. The depth of the burrow to the bottom of the cells was sometimes four inches; the depth above the highest cell varied from three-fourths of an inch to two inches. The diameter of the burrow was one-fourth inch.

In three-fourths of the nests that I opened were two cells; the remainder of the nests had only one cell. The cells were always one below the other in the direct line of the burrow, never at one side.

In form the cell varied from globular to barrel-shaped. In size there was also considerable variation. Cells excavated in the same locality, in the same kind of soil and under the same conditions showed noticeable variations both in shape and size. Sometimes cells in the same nest differed markedly from each other. The extent of this variation may be shown by a comparison of measurements of cells of four nests located in open spaces in a pasture within seventy-five feet of each other. The descriptions of these cells as given in my notes are as follows:

Nest 1.—Two cells; globular. Cell 1—vertical diameter, 10/16 in.; horizontal diameter, same. Cell 2—vertical diameter, 11/16 in.; horizontal diameter, 10/16 in.

Nest 2.—One cell; globular. Vertical diameter, 10/16 in.; horizontal diameter, 11/16 in.

Nest 3.—Two cells; barrel-shaped. Cell 1—vertical diameter, 14/16 in.; horizontal diameter, 1/2 in.

Nest 4.—One cell; barrel-shaped. Vertical diameter, 3/4 in.; horizontal diameter, 1/2 in.

No tube was built over the entrance of this burrow, as is the case with so many of this genus, but the earth excavated was not left about the nest. The pellets are dropped in piles from eighteen inches to two feet from the entrance.

When the nest was stored with caterpillars, *O. dorsalis* did not stuff the burrow with earth. She simply closed the cell,

and then sealed the entrance to the burrow, always leaving a long vacant space in the burrow above the upper cell. The thickness of this mud plug which she puts in the entrance of the burrow I have found to vary from one-eighth to seven-sixteenths of an inch. The plug with which the cells were closed varied in thickness from one-eighth to five-sixteenths of an inch.

The locality of the nest, after it was closed, was often betrayed by a small basin-like depression, of which the closed entrance to the burrow was the center. The depression varies from one-half to three-fourths of an inch in diameter. It was caused by the removal of earth from the edges of the burrow entrance, to be used in sealing the burrow.

The nests whose entrances opened in the face of the earthen bank were similar to those already described, in that the cells were arranged one above the other as a series of enlargements of the burrow at its lower end. The cells were nearly all vertical, as was most of the burrow above the cells, although it entered the bank horizontally.

The number of cells to each nest was a marked difference between the nests of this colony and those previously described. The eight nests had a total of thirty-seven cells; the smallest number of cells in one nest was three; the largest number, seven. With one exception, the cells were arranged in a single gallery. The cells of the one nest which did not conform were in two galleries of four and three cells each, one excavated directly behind the other.

The cells in this colony were quite nearly alike in shape and size. All resembled barrels with rounded ends. The average height was fifteen-sixteenths of an inch; the average diameter one-half inch. The burrow before it reached the cells was from one to three inches long. Its diameter averaged nine-thirty-seconds of an inch. The depth depended upon the number of cells in the nest. In one in which there were six cells the base was eight inches below the entrance. The entrances to the burrows and the cells were sealed with mud plugs varying from one-eighth to one-fourth inch in thickness.

Let us now observe the building of a nest. A female *dorsalis*, running nervously over an open space about the size of my hand, in an Osborne county bottom-land pasture, attracted my attention. She would stop for an instant, and with her fore feet would sweep dust rapidly under her body. Then she

would run back and forth again, stopping occasionally in different parts of the open space to repeat the sweeping. This lasted for about five minutes, when, after concentrating her sweeping on an area of about one square inch, clearing it of loose earth and blades of grass, she took wing, made a circling, zigzag flight over the scene of her activities, and flew away in the direction of the river.

I remembered that *O. papagorum* and *O. arvensis* had behaved similarly before beginning work on a nest, so I sat down on the grass as near the open space as I dared and awaited developments.

In forty seconds she returned, wet a spot in the little area she had cleared, and began to dig with her mandibles and fore feet, gathering the earth into a pellet, which she held in her mandibles. After digging thirty seconds she arose and dropped the pellet about eighteen inches from the hole. All the other pellets she excavated were dropped about the same place. Trips for water followed regularly after removing every five or six pellets of earth.

To ascertain how much time was spent in carrying water, how much in extracting each pellet of earth, and how much variation there was in the time spent on each part of the work, I timed this wasp's trips. I kept the time record in detail in my notes, showing the number of seconds used for each trip for water and for removing each pellet of earth. I shall here give the first part of this record from my notes. All numbers, represent seconds. It follows:

For water, 40; for removing pellet, 30, 15, 25, 20, 20.
For water, 40; for removing pellet, 30, 25, 15, 25, 20, 20.
For water, 30; for removing pellet, 15, 20, 20, 15, 30, 40.
For water, 25; for removing pellet, 10, 30, 25, 35, 15.
For water, 35; for removing pellet, 30, 30, 30, 15, 20, etc.

Madam *Dorsalis* worked very steadily, never pausing while in the vicinity of the burrow. She would take wing the instant she backed out of the burrrow, and on dropping the pellet would fly directly back to it.

She worked steadily from 10:35 A. M. until 11:15 A. M. During those forty minutes she had removed eighty-six pellets and made sixteen trips for water. Most of the time she had been completely hidden while digging. When she returned from her seventeenth trip for water she flew to the burrow and started to enter, but when half way in she stopped sud-

denly and backed out. For a minute or two she seemed undecided. Several times she put her head into the burrow but did not enter. Then she located a new nesting site, two and one-half inches from the first one, clearing the ground by sweeping with her front feet, as before. At 11:19 she brought her first load of water and began work on her second burrow.

The depth of the deserted burrow, which this wasp had dug in forty minutes, the result of a total of 102 trips for water and for removing earth, was one and three-fourths inches. I could find no cause for the desertion of this nest.

O. dorsalis worked on the second burrow as industriously as she had on the first, and much in the same manner. At 1:05 P. M. she stopped digging and flew away over the pasture in search of caterpillars, storing six in one hour and five minutes. After depositing the sixth caterpillar she came out of the burrow, then backed into it, staying inside about three minutes—I supposed to oviposit. Then she flew away toward the river, and on returning entered the burrow. Later, when I opened the nest, I found that she had used earth from the sides of the burrow to furnish material with which to seal the entrance to the cell.

Sealing the mouth of the burrow was the next work. Earth at the edges of the burrow's entrance was moistened, then removed and applied to the sides of the burrow's entrance. When enough earth had been removed to completely close the burrow a basin-like depression was left. The process of sealing the entrance to the burrow occupied nine minutes. Two trips for water were made, each occupying thirty seconds.

This wasp had completed the entire work of excavating her nest, storing and closing it in three hours and five minutes. The burrow, which was two and one-eighth inches deep, was excavated in one hour and forty-five minutes.

One of the wasps I observed dug somewhat faster than the one just described. In one hour and twenty-five minutes she excavated a burrow with one cell, three inches deep, in contrast to one hour and forty-five minutes required to excavate a burrow two and one-eighth inches deep. For eight and one-half minutes I timed her trips. During that time she went for water four times and removed twenty-two pellets. The trips for water required about the same time as those of the first wasp, but the removal of a pellet of earth required only seventeen seconds on the average, while with the first wasp this

average was twenty-two seconds. The two wasps worked under the same conditions, as far as that is possible. Both nests were in the same open space, being within three inches of each other. They also had the same advantages of temperature, for I was watching both nests at the same time. The second wasp began working ten minutes after the first one had begun her second nest. Although the second wasp worked more rapidly in digging, it took her twice as long to store six caterpillars in her nest.

Two other nests, whose progress I had kept note of from their commencement until their completion, required a much longer time for this process. One was closed twenty-one hours after it had been begun; the other was closed twenty-five hours after its commencement. Both were nests with two cells.

Two hesperid caterpillars were preyed upon by *O. dorsalis*. The larvæ of the spotted skipper (*Pyrgus tesselata*) was taken by *O. dorsalis* exclusively in Russell and Osborne counties; the larvæ of the black skipper (*Philosara catullus*) was the only caterpillar that I found in its burrows. The first caterpillar was common on the poppy mellow (*Callirhœ involucrata*), an abundant and conspicuous plant in many lowland pastures. I always found the larvæ in a nest made of a crumpled leaf or two, whose edges were held together by a silken web. Sometimes this web was in the heart of the plant. The black skipper larva Mr. Williams collected on the pigweed (*Amayranthus retroflexus*).

One afternoon of the first week in August, at about 3:20 o'clock, I stationed myself before a burrow to watch particularly the storing of prey. In fifteen minutes the wasp visited the burrow, but brought nothing. She left the nest quickly, and in two and one-half minutes returned with a caterpillar. Two minutes were required in storing it. She brought another caterpillar in fifteen minutes, again staying in the nest three minutes. The next caterpillar was brought in two and one-half minutes. She then spent twelve minutes in the field, and returned with nothing. She brought a fourth caterpillar in fifteen minutes and stored it in three minutes more.

Evidently the cell was full, for when she came out Mrs. Wasp flew in the direction of the river and returned in a minute with her mouth parts glistening. She stayed in the burrow two minutes, presumably to close the cell. Then she

came out and quickly backed into the nest. Probably she backed in to oviposit in the empty upper cell. She stayed in two minutes, and then went to the field again. In two minutes she had brought a caterpillar. Here I left her for the day.

The next morning soon after 7 o'clock I was waiting at the door of the burrow. At 7:35 her head appeared in the doorway. Evidently she had backed into her burrow and spent the night there. She waited there until 7:48, and then took wing. Her morning's hunt was entirely unsuccessful as far as I observed it. Perhaps the comparative coolness of the morning affected her. She made six successive trips to the field and returned each time without prey. The time required for these trips, respectively, was as follows: 16, 12, 21, 15, 12 and 15 minutes. The purpose of her return seemed to be to inspect the nest. After her second trip to the field it appeared that she was about to begin further excavations in her burrow. She carried out three pellets, the removal of each one requiring about a minute. She then returned to the hunt.

After her sixth "empty-handed" return to her nest I followed the wasp to the field, to learn, if possible, the cause of her lack of success. She seemed to be in earnest about hunting. She would fly from one mallow plant to another, running over the leaves and stems. Twice she found a caterpillar and struggled with its web, but did not seem able to dislodge the inmate. In one of these instances she worked four minutes trying to tear open a caterpillar's nest before she gave it up. Another time she was successful in dislodging a caterpillar, stung it twice, and then dropped it. She then continued hunting on the same plant, and once actually walked over the prostrate caterpillar, but did not appear to notice it. After following her for twelve minutes I left her. I returned to the nest an hour and a half later and found her closing it. She at once located a new nesting site within a few inches of the first one and began excavations for another nest. By noon and throughout the afternoon she was again carrying caterpillars as busily as she had been the day before. Both nests were two-celled.

O. dorsalis was easy to follow while hunting in a mallow patch. The plants were small and spreading and could not hide her movements. Her flights from plant to plant were short, and she spent considerable time running over each plant. She seldom seemed sensitive to observation, and her large size

made her conspicuous. The situation in Osborne county was made still easier for study because the nests of *O. dorsalis* were located in a pasture overgrown with the poppy mallow. This often made it possible for me to follow a wasp from the nest to the field, and after having observed the capture of a caterpillar to run back to the nest before she had pushed the caterpillar in.

When *O. dorsalis* would come upon a crumpled leaf containing the larva of the spotted skipper, she would commence tearing energetically at the silken nest, first at one end, then at the other. Although the wasp worked furiously and without pausing, sometimes more than five minutes were required to dislodge the caterpillar. Usually, however, in less than a minute the caterpillar would be jerked violently from its cover, seized by the neck, and stung two or three times under the thorax. Once I saw a wasp seize a caterpillar by the tip of the abdomen to jerk it out of its nest, and sting it under one of the last abdominal segments. Then she quickly seized its neck and gave it three thrusts under the thorax. A vigorous maxalation invariably followed the stinging. The capture of a caterpillar generally occasioned considerable excitement on the part of the wasp. Sometimes she would lose her footing, and both insects would roll from the leaf to the ground before the victim could be subdued.

After maxalation, without further delay the caterpillar is carried to the nest. *O. dorsalis* always carried the caterpillar in the same manner as did all the others of the genus that I have observed. The caterpillar, head foremost and ventral side up, is grasped by the wasp's mandibles and one pair of legs. The wasp always flew directly to the burrow. Her flight was usually quite slow, for the caterpillar seemed to be a heavy burden. On alighting the caterpillar was pushed ahead of her into the burrow, and the wasp, seizing its last abdominal segment, followed it in. *O. dorsalis* was always in a hurry.

The number of caterpillars in a cell, with the exception of three cells, varied from five to seven. In Graham county, August 19, I opened a nest with two cells containing three and two caterpillars, respectively. A week later, in Norton county, I opened a two-celled nest, containing five and two in each cell, respectively. The caterpillars were all about the same size. They were stored in a more or less tangled mass. In many

instances the cell was packed; sometimes I would find a fair-sized space above the caterpillars.

All of the caterpillars that I took from nests of *O. dorsalis* showed signs of life. The abdominal segments invariably responded to stimulation. However, I found none as active as some stored by *O. papagorum* and *O. arvensis*.

The egg was usually suspended from the ceiling of the cell by a white thread, sometimes as long as the egg itself. In an exceptional case the egg was on a caterpillar, being attached by a thread to its seventh abdominal segment. This caterpillar was on the bottom of the cell and was probably the first one stored.

Although attached to the ceiling, the egg is not always suspended above the caterpillars. It was only in exceptional cases—in unusually large cells—that I found it so. I have found it hanging among the caterpillars. Usually I could not find the egg at all until some of the caterpillars had been removed.

The time of oviposition, in relation to the storing of the nest, probably varies. On one occasion I noted a wasp back into its cell after it had been stored, supposedly for oviposition, and just before it had been sealed up. I concluded then that oviposition takes place after the storing of the caterpillars. My conclusion was upset when I saw a wasp back into a new cell in which nothing had yet been stored. Several times I found eggs suspended in cells only partially stored, and twice in cells that were entirely empty. I also opened a number of empty cells in which I found no egg.

The egg of *O. dorsalis* is ellipsoidal and rounded at the ends. Its length is about 4.5 mm. and its greatest diameter is 1.5 mm. It was more nearly flattened at the end of attachment to the thread. It was also less rounded on one side than on another. Its shape reminded me of that of a cucumber. In color the egg was creamy white. The thread attachment was white and about the same length as the egg.

But one *O. dorsalis* grub came under my observation. Mr. Williams saw a wasp closing its nest on the afternoon of August 7. He marked the place and showed it to me. Five days later I opened the nest. It had one cell containing seven caterpillars and a grub, which I should judge was about one-third grown. In appearance this grub was like those of other

species of this genus, very stout, being larger near the anal end, and whitish in color.

The last of the pupal stage I had opportunity to observe in the bank colony of nests. Two pupæ, almost ready to disclose wasps, were taken from the lower two cells in a gallery of four. In another nest in the lowest cell another pupa was taken. The rest of the nests were empty. I placed these pupæ in glass vials. One disclosed the next day and the other two disclosed on the third day after I had taken them. All were females. These pupæ were colored almost like the adults, except that the rufous on the abdomen was lighter, and the yellow ornaments were pallid. All were resting on the tips of their abdomens, with their heads upward.

My attention was attracted to the location of the bank colony by a number of males of *O. dorsalis* which collected on the face of the bank around openings to these nests from which wasps had emerged. Occasionally one of the males would inspect the entrance of all the open burrows in the bank. At two of the burrows these males always stopped to put in their heads, and sometimes one would enter part way. While he would fly to the others in the course of his circuit, Mr. Wasp would stop at them only momentarily, and then take wing again. The two burrows in which the males manifested such a special interest proved to be the ones which contained the female pupæ nearly ready to be disclosed.

These males were very quarrelsome. Often when one would put his head into the burrow another would dash at it, and together they would fall to the base of the cliff. Occasionally they would dash at each other without any evident provocation.

From the fact that only females were found in the lower cells of these nests, and that males were waiting apparently for their emergence at the mouths of the burrows, I should judge that males emerge first, as in the case of others of this genus. Perhaps the upper cells of the galleries, which were empty, had contained these males.

In a number of the empty cells of this colony I found heads of caterpillars, probably hesperids, evidently discarded by the wasp grub.

O. dorsalis had an abundance of insect enemies. The findings in the cells of the bank colony may suggest the extent to which other insects interfere with their increase of numbers.

Of thirty-seven cells opened at least eighteen did not produce *O. dorsalis.* In one of these eighteen cells I found the pupa of a bombyliid, probably of the genus *Anthrax.* In one of these cells was an empty pupal case, probably of a chrysidid. In the walls of two other cells I found tachinid flies. These flies had endeavored to break their way out of the cells by burrowing into the wall, and had perished. In the remaining fourteen cells were found many dipterous pupal cases, perhaps also tachinid. These flies may have been parasitic upon the caterpillars stored, but at any rate they prevented the development of the wasps.

I opened a two-celled nest in Rooks county in the upper cell of which were seven recently stored caterpillars; in the lower cell were only caterpillar skins and many almost minute springtails. I once took a mutillid (*Mutilla simillima*) in a nest. The cuckoo bee (*Chrysis intrica*) was so closely related to the nesting activities of *O. dorsalis* that I shall deal with it separately. I have taken a large robber fly (*Deromya* sp.) carrying this wasp.

Chrysis intrica always attended the excavation and storing of the nests of *O. dorsalis.* I never watched the domestic activities of this wasp but that a cuckoo bee was present. The *Odynerus* could scarcely begin digging before one of these ubiquitous parasites would appear. *Chrysis* would wait patiently, facing the nest, on the tip of a grass blade a few inches away. It manifested its interest in the proceedings by darting into the burrow occasionally, and then hurriedly resuming its position on the grass blade. Sometimes it would even enter the burrow when the wasp was within. Often there would be two or three cuckoo bees waiting around one burrow.

Ordinarily the wasp and the cuckoo bee seemed to pay little attention to each other. The cuckoo bee was nearly always motionless in the wasp's presence. When the wasp did dash at the cuckoo bee it would take wing or drop into the grass. The wasp was never successful in catching it. When the wasp would go back to work the cuckoo bee would resume its position. Three times I saw *O. dorsalis* carry *Chrysis* out of her nest with her mandibles; but each time she dropped the parasite like a pellet of earth, and left it apparently unharmed.

On one occasion Mr. Williams and I watched *Chrysis* break into a nest of *O. dorsalis* after it had been sealed up. The wasp had closed its burrow entirely and had gone for water with

which to melt some mud for the finishing touches. Suddenly the cuckoo bee, that had been passively waiting for some time, seemed to realize that she was about to be shut out. She flew to the nest, and with little difficulty made an opening in the cap, and disappeared just before the owner of the nest returned. Upon alighting the wasp paused a moment. She saw instantly that something was wrong. She then tore out entirely the cap she had so carefully made, and rushed into the burrow. She soon reappeared with the intruder in her mandibles, and dropped her on a pile of pellets. She then went for another load of water and again sealed up the burrow. *Chrysis* took her position on the grass blade and watched the proceedings, but did not again interfere.

O. dorsalis had a tendency to nest in colonies. I sometimes found an isolated nest, but usually the nests were in small groups, sometimes as many as eight. Usually only two or three wasps would share an open space in a pasture, each wasp digging one or two nests. I never found them in populous colonies like those of *O. papagorum.*

These wasps sometimes manifested considerable curiosity in each other's work. This characteristic I first noticed in two wasps digging in an open space within three inches of each other. When one was gone for water the other would sometimes leave its work and inspect the work of the absent party by putting its head into the entrance. However, I never saw a visitor presuming to enter. The visitor would always hastily return to its own burrow at the near approach of the owner of the inspected burrow. I never saw the females of this species quarrel.

O. dorsalis was always most active during the heat of the day. On bright sunny days during the nesting season the wasp was apparently busy from eight o'clock in the morning until near sundown.

O. dorsalis seemed to be the most cautious of all the members of this genus about floating upon water. Some individuals would float upon pools, but never upon running water. On a gravel bar on the Solomon river I watched one of these wasps come for water. She would alight about six inches from the water's edge and would walk out to it. When on water, or at work elsewhere, *O. dorsalis* always kept its wings spread and raised at an oblique angle from the thorax, ready to take flight at any instant.

I sometimes collected males of this species on sand or gravel bars by streams, where they were apparently sunning themselves. They were never abundant there, however, as was *O. arvensis.*

O. dorsalis never seemed to have any difficulty in finding her way to her burrow after a trip to the field. Usually she flew directly to it; I never saw her do otherwise when she was returning from the field with prey. At times when she returned from the field unladen, I have seen her pause at another burrow in the colony. This action may have been prompted by curiosity instead of being a mistake in location. I have noted a number of these wasps make a locality study above a spot selected for a nesting site.

Although not generally sensitive to observation, *O. dorsalis* was more responsive to changes in the surroundings of her burrow than was *O. papagorum.* A few marks with a knife, to assist in locating a nest at a later time, seemed to disturb one wasp considerably. On her return to the nest she made a prolonged observation flight of irregular circles above her nest, while she had been in the habit of alighting without any hesitation. On another occasion I mutilated slightly the entrance to a burrow. Upon the wasp's return she circled around the burrow a few times and then alighted about two inches from the entrance. She flew away and returned in about a minute and repeated the observation performance. Again she flew away and returned without entering. This time she apparently deserted the nest.

Pterochilus 5-faciatus Say.

In the middle of a sandy road, beside the Saline river, Mr. Williams and Mr. Mallory noticed a large eumenid dragging a long caterpillar under her body. I was only a short distance away, and they called me to see it. The eumenid entered a thicket of *Chenepodium,* dragged the caterpillar to a large hole about two feet from the roadside, and entered it quickly, still dragging the caterpillar under her body.

We left *Pterochilus 5-faciatus* there—for she was so identified later—and continued on our way to locate and pitch a temporary camp. This observation was made at 12:30 P. M., July 24.

I returned to the nesting site at 3:40 P. M., and *Pterochilus* appeared twenty-five minutes later. She brought nothing, but

alighted in the middle of the road, ran into the weeds to her burrow and entered. A minute later she came out, not backwards as do the members of the genus *Odynerus*, but head foremost. She always came out in this manner. She walked deliberately to the open road before she took flight. Again in twelve minutes she came, unburdened as before, and repeated her visit to the nest, staying a minute. In fifteen minutes she returned with a caterpillar. In my eagerness to observe every movement I moved forward slightly and she seemed to notice me. She poised a moment, then flew high in the air and out of sight. She returned in fifteen minutes, but without prey. This time she stayed about three minutes. She again flew away and had not returned by six o'clock, when I left for camp.

Madam *Pterochilus* was filling her nest with sand when I returned the next morning at 8:30 o'clock. With her front feet she would vigorously scrape together a heap of loose sand near her burrow, and then push it with her front feet into the entrance. After pushing in several heaps she would go down, no doubt to press it in place more firmly. In less than five minutes the burrow was practically filled. I took her then for identification. No water had been used in closing the burrow.

I then opened the nest. It was excavated in very sandy soil. The burrow led to two horizontal galleries, one of which terminated in a single cell and the other in three. The main burrow was two and three-fourths inches deep and seven-sixteenths of an inch in diameter—almost twice the diameter of the burrow of *O. dorsalis*, a wasp of nearly the same size. The direction of the burrow was obliquely downward, with but one break in its course. None of the cells were in the direct line of the main burrow, nor did any of them open directly into the burrow. At its bottom the burrow branched abruptly into two horizontal burrows leading in opposite directions. One side burrow was only one inch long before it reached the single cell. The other side burrow was two and one-fourth inches long before it reached the first cell of the gallery. When packed with sand the burrows were quite hard to follow.

The cells were shaped like short casks, lying on their sides. In the gallery with three cells they were arranged one behind the other. The cells averaged three-fourths of an inch in length by ten-sixteenths of an inch in diameter. The partitions between them were of sand, and were from one-sixteenth to

one-eighth of an inch in thickness. The particles of sand in the partitions seemed to adhere much better than the sand in the tube. This led me to think that some fluid had been added to it.

All of the cells were supplied with caterpillars. In one cell two were stored; in another were four, and in each of the others were three. The caterpillar was a rather stout, naked noctuid. In color it was light green; it had two rows of black dots on each side and many white lines on its back and sides. It was from 23 mm. to 25 mm. long.

Two eggs were found. They were suspended from the ceiling of the cells at the end farthest from the entrance. The eggs were shaped like those of *Odynerus*. They were 3.75 mm. long by 1.2 mm. in diameter. The threads by which they were suspended were about the same length as the eggs.

This wasp's manner of return to her nest was noteworthy. She would always alight in the middle of the sand, and then go directly through the weeds to her burrow. She did not always fly directly to the road, however, on her return trips. On several occasions she circled over the *Chenipodium* patch before alighting. Perhaps she was disturbed by my presence. When leaving the nest she always went into the open before taking wing. On coming to the nest she would always appear high in the air, and on leaving she would always rise high at the start. This high flight may have been because her hunting ground was a long distance from her nest.

Another burrow of *Pterochilus 5-faciatus* I found in a sandy bank by the Smoky Hill river. While walking along the edge of the stream I saw a large wasp dash from a burrow. Thinking she was a bembecid, I swept at her with my net and quickly put her in my killing bottle, and so spoiled the opportunity for observation.

When I saw that I had taken a eumenid I opened the burrow. I found just a straight burrow three inches deep leading obliquely into the sand. This burrow was located in a barren bank of loose sand about four feet above the river and not ten feet from its edge. The observation was made July 12.

Odynerus hildagi Saussure.

While watching the nest-building of *O. papagorum* in cliffs in Ness county, my attention was attracted to a medium-sized *Odynerus* also entering a burrow in the face of the cliff. Later

investigations proved this wasp to be *O. hildagi*. The following observations were made on the afternoon of July 6 after 4:30 o'clock.

This mother wasp was busy storing her nest with caterpillars when I observed her. She used the same caterpillar that was the prey of *O. papagorum*. It was very small in proportion to the wasp and was handled with apparent ease.

The wasp always flew directly to the burrow, carrying the caterpillar, ventral side up, under her body. She grasped the caterpillar by the neck with her mandibles, and also held it about the abdomen with her middle pair of legs. When she reached the burrow she hastily thrust the caterpillar ahead of her, holding one of its last segments with her mandibles as she disappeared.

After she had stored eight caterpillars in my presence, Madam Wasp returned from her ninth trip with a pellet of mud, evidently from the creek. She worked inside the burrow five minutes, backed out, paused a moment at the entrance, and went in again. Again she came out and reëntered without taking wing. When she came out the next time she stood on the edge of the burrow and tried to back in, presumably to oviposit. But she failed to back in, for she thrust the tip of her abdomen against the side of the cliff instead of into the burrow.

Then followed the most ludicrous performance I had ever known a eumenid to be responsible for. Eleven times in succession this wasp stood with all six legs on the rim of the burrow entrance and tried to curve her abdomen under her, apparently to thrust it into the burrow. Instead of doing this, each time she thrust the tip of her abdomen against the cliff side at the burrow's edge. After each failure she would turn around and peer wonderingly into the burrow to see what the trouble might be. Sometimes she would go half way into the burrow. After each investigation she would again poise on the rim of the burrow and again try to back into it.

Her twelfth attempt was partially successful. She would have succeeded had she pushed the tips of her wings into the burrow as well as her abdomen; but one of them caught in the edge. She could back into the burrow only to the point of the wing's attachment on her thorax. Three minutes of struggling failed to free the wing or to bend it. She came out

and reëntered the burrow head first. Twice more she tried to enter the burrow and failed. Then in evident disgust she flew away.

In eight minutes she returned, entered the burrow, came out quickly, and again tried backing into it. Her third attempt was successful. This time both of her wings caught outside of the rim of the burrow, but by several minutes of pulling and twisting she bent them so that she could enter.

She stayed in the burrow four minutes, and then at once began storing more caterpillars. After her sixth trip I caught her for identification.

This wasp was the fastest worker of all the members of this genus that I had observed. The time she spent inside the burrow storing her caterpillar varied from five to eight seconds. She entered the burrow quickly and did not waste a moment, starting on the hunt as soon as she had backed out. Also she was the quickest to return to her nest with prey. Seven of the hunting trips which she made before trying to oviposit I timed as follows: 7, 6, 3, 4, 4, 6, and 7 minutes, respectively. After oviposition the time of the trips was as follows: 5, 1½, 3, 4, 8, and 7, respectively. This wasp could go to the field, bring in a caterpillar and store it in the average time required by *O. papagorum* for the storing process alone.

After taking the wasp I opened the nest. It contained four cells, three in one gallery, and one cell directly behind this gallery. As the burrow entered the cliff it pointed in horizontally and then curved downward. The cells were practically vertical, and were arranged one above the other.

The base of the lowest cell was about three inches below the entrance of the burrow. The burrow at the entrance was nearly one-fourth of an inch in diameter. The cells were ten-sixteenths of an inch long and six-sixteenths of an inch in their widest diameter.

These cells were built in the cliff; they were not simply excavated, but were distinct from the earth that surrounded them, so that when it was removed I was able to take out the cells and remove them to a box. When removed, these so closely resembled the much larger cells of *Anthrophora occidentalis* that I was led to believe that the wasp did not build this nest, but preëmpted a nest of one of the smaller digger

bees. The nest was lined with a kind of paper, and so was the burrow.

The upper of these cells contained the six caterpillars that I had seen stored, and an egg suspended from the roof of the cell, in a manner similar to that of the other eumenids that I observed. The next cell was packed with caterpillars, eighteen of them, but I did not find the egg. All the caterpillars that I investigated responded to stimulation.

The two remaining cells I left unopened and kept in a tin box. On September 14 a male wasp emerged from one of them, at least two months and eight days after the cell had been stored. Instead of breaking open the cap of the cell when he emerged, this wasp cut out a circular hole in the side of the cell. He was influenced in this, no doubt, because the cell lay on its side in the box instead of upright as it should have done naturally. The length of time spent by the wasp within the cell may also have been affected by the abnormal conditions.

O. hildagi is a rare wasp in western Kansas. But four specimens were taken during the summer's trip.

Odynerus sulphuritinctus Vierick.

A single female of this species was taken by Mr. Williams, coming out of an old mud dauber's nest, located under a ledge in the chalk cliffs on the Smoky Hill river in Trego county. It was the only specimen of this species taken during the summer. It was taken July 10.

Eumenes bolli Cresson.

On tall prairie grass and weeds in a ravine in a Ness county I found a favorite night resort for thread-waisted sphecids of the genus *Ammophila.* There, more or less protected from wind, they would collect in the evening to spend the night, grasping the grass stems with their mandibles and legs, holding their bodies rigidly away from the stems. A number of scoliids was also collected in this ravine, resting on horizontal branches of weeds and on grass blades. There also I found a solitary *Eumenes bolli.*

This wasp was hanging on a horizontal branch of *Dalea* sp. It did not hold its body rigid and in line with the stem as did the *Ammophila,* but held itself at right angles to the stem, with its long petiolate abdomen curled under it. With its legs it

held the branch above and with its mandibles it griped the leaf which was attached to the branch between its fore legs. This was taken July 6.

Two others of this species were taken the next week in Trego county. One was flying along the dry bed of an intermittent stream and the other was taken on the leaves of a solitary cottonwood tree. This species was observed on two other occasions during the summer—once by Mr. Williams, on August 2, in Osborne county, flying over a prairie hillside. On the other occasion, August 26, in Norton county, I noted *Eumenes bolli* take water at a stock tank in an open pasture. She did not alight directly on the water, but on a sunflower leaf floating in the tank.

Three jug-shaped nests of *Eumenes* were found during the summer. The first was found by Mr. Williams on July 24, in Russell county. This nest was in a ravine, attached to a branch of *Onosmodium molle,* about eighteen inches above the ground. The nest had apparently been built and then deserted. A second nest I found on August 8, in Rooks county, in a ravine, attached to a branch of *Euphorbia marginata.* This nest had a circular opening in its top—not through the mouth of the jug—from which the wasp had evidently emerged. The next day I found a third nest, attached to a twig of *Rhus canadensis,* about two and one-half feet above the ground. This shrub was growing on the side of a sand dune. From this third nest a male *Eumenes bolli* emerged August 28. One of these nests was within 50 yards of water. The other two were each about 400 yards from water.

Nests of *Eumenes* have previously been described by others as jug-shaped cells. The cells of *E. bolli* were like shortened jugs, which, not considering the mouth, were nearly globular. The side which was attached to the more or less upright plant stem was somewhat flattened. The flaring mouth opened near the middle or above the middle of the side opposite the point of attachment. The diameter of the jug varied from one-half to nine-sixteenths of an inch. The entrance in the mouth was three-sixteenths of an inch in diameter. On the exterior of the jug were small rounded ridges and some rounded prominences, showing how the layers of earth had been added by the potter. However, the surface was smooth, not granular. These nests are made of earth, but I have thought that some-

thing besides water—perhaps saliva—must be mixed with the earth to insure the permanence of the nests through various kinds of weather.

Eumenes fraternus Say.

A two-celled nest of *E. fraternus* was found by C. H. Withington on a dogwood branch, March 6, 1909. At the time the nest was taken it contained full-grown larvæ. Two female wasps emerged May 10, 1909. The nests and wasps, with an explanatory note, were placed in the Snow collections.

The cells of this nest were two earthen jugs attached to each other so that one lateral wall served for both. They were similar in shape and size to the nests of *E. bolli*, but were flattened beneath where they were attached to the horizontal branch of dogwood. While alike in general plan, these nests showed considerable variation in structure. One was higher, more covex above and more nearly round; the other was considerably larger. One nest was placed with its long axis at right angles to the direction of the branch; the other obliquely to it.

Eumenes sp.

A jug-shaped cell, somewhat like those of *O. bolli*, was brought to me by Will H. Collins, a student of entomology at Kansas University, October 21. This nest he had found attached to the upper surface of a flat stone, in a wood about three miles south of the University campus. The lower side of the cell, where it was in contact with the stone, was much flattened. Otherwise it was similar in appearance to the nest of *E. bolli*. Two reperesentatives of this genus have been taken in Douglas county—*E. fraternus* and *E. smithi*.

SUMMARY.

I shall now summarize some of the data that can readily be grouped.

Eumenidæ are friends of plant life. The adult insects are to a certain extent flower pollenizers. From Mr. Hartman's observations on *O. dorsalis* we learn that the adults sometimes also take animal food for themselves. The food of the wasp grubs, as far as is known, is exclusively plant-feeding larvæ of other insects. Some of these larvæ preyed upon are obscure species, making the work of wasps that prey upon them neutral so far as economic importance goes. There are many other

instances of eumenids destroying insects of considerable economic importance. Representatives of the following families are recorded as being destroyed by eumenids: Lepidoptera—Notuidæ, Pyralidæ, Hesperidæ, Tortricidæ, Geometridæ, and Œcophoridæ; Coleoptera—Curculionidæ and Scurabidæ; Hymenoptera—Tenthredinidæ.

The economic insects destroyed by eumenids that are noted in this paper are as follows: Cutworms, destroyed by *Monobia quadridens,* noted by Ashmead; canker-worms, noted by Harris and the parsnip web-worm (*Depressaria hearcliana*), noted by Southwick, both destroyed by *Eumenes fraternus;* the Larch sawfly (*Nematus erichsonii*), destroyed by *O. capra,* observed by Fyles; *Pempelia gleditschiella,* destroyed by a small *Odynerus,* observed by Marlatt; the cotton worm, destroyed by *O. dorsalis,* observed by Hartman; *Loxostege stricticalis,* destroyed by *O. annulatus,* observed by Hungerford and Williams; the same caterpillar, destroyed by O. *arvensis,* observed by myself.

A comparison of four species that I observed indicates that the tube which some species construct over the entrance of their burrows is of value in excluding parasites. The observations are too few to serve as anything more than an indication of this. *O. dorsalis,* which built no tube, was heavily parasitized, while *O. papagorum, O. arvensis,* and *O. annulatus,* all tube builders, seemed little troubled with parasites.

The most persistent parasites of the Eumenidæ are in the family Chrysididæ. Other families, representatives of which have been found in nests of eumenids, are: Diptera—Bombyliidæ and Tachinidæ; Hymenoptera—Ichneumanidæ, Braconidæ, Mutilidæ, and Myrmicidæ. Aptera—robber flies (Asilidæ)—may also be listed as enemies of the Eumenidæ, although they have not been taken in nests of eumenids.

The purpose of the suspension of the egg from the roof of the cell can not be, for all species, as Fabre suggests, to prevent the egg from coming in contact with the writhing larvæ. If this is the purpose of the suspensory thread, it is unsuccessful in many cases. In the observations of the Peckhams on the nests of *O. anormis,* and in my own observations on four species, *O. papagorum, O. dorsalis, O. annulatus* and *O. arvensis,* the egg was found among the caterpillars. Riley refers to Harris as stating that the nest of *E. fraternus* was packed

with caterpillars, which suggests that the egg could scarcely have been suspended above them. Mr. Hartman's experiment with the egg of *O. arvensis* showed that being among a number of very lively caterpillars did not injure the egg or the young wasp larvæ, at least in that instance.

The arrangement of caterpillars, as in the nest of *O. reniformis* which Fabre described, so that the wasp larvæ could eat caterpillars in the order in which they were stored, can scarcely apply to many species of *Odynerus*. In all of the nests that I observed the caterpillars were not stored so that the wasp larvæ would be able to select them in the order in which they were stored. With some wasps that stored their cells within one or two hours, the order of storing could have made little difference in the relative strength of the different caterpillars.

I collected some data on the observing ability of four eumin-ids. This evidence is not sufficient to base any conclusions upon, and a part of it is contradictory.

O. papagorum, O. arvensis and *O. dorsalis* all made locality studies before beginning work on a burrow. This one locality study before the beginning of work was the only one I ever observed any of these wasps make, if undisturbed. They always flew directly to the burrow, because, I had supposed, they had an accurate memory of their immediate surroundings. *O. annulatus* frequently made a short locality study before alighting at her burrow.

When I put sunflowers in the midst of a colony of *O. papagorum,* mutilated a number of nests in another colony, and disfigured the face of the cliff for several inches around the colony, none of the owners of nests seemed to be disturbed, and at first only one wasp seemed to even notice the change. They flew as directly to their nests as before. If these wasps had any observational ability at all, why were they not alarmed by the depredations about their nests? How did they know that those nests that they entered so confidently were their own? Could they have been guided by a sense of direction and not by memory of the surroundings of their nests?

O. dorsalis usually noticed a few marks about her nest, but only once did she seem to resent changes for any length of time. In this instance I had cut away a part of the entrance to her burrow, and she deserted it. The same was true of this

species as observed by Mr. Hartman. When he pulled up the grass before her nest she was disturbed only for the moment. Neither *O. papagorum* nor *O. dorsalis* objected to being observed.

O. annulatus was sensitive even to my presence in the vicinity of her nest, and sometimes delayed work because of it. None of these species were as extreme in sensitiveness as *O. vagus,* mentioned by the Peckhams, which delayed work for half an hour because of a red match head within two inches of her burrow.

It was interesting to me to note that *O. annulatus,* which seemed to be the most plastic in habits of all the species I observed, was also apparently the best observer. *O. papagorum,* whose habits seemed inflexible, at least in the choice of a nesting site, appeared to be a very poor observer.

A fact that greatly impressed me in my study, and that sometimes astonished me, was the variability in habits exhibited by members of this family. I had expected the different species of the family to differ from each other, but a wide variation was often exhibited by members of a species.

Within the species *O. annulatus* I found one lazy individual that used a vacated mud dauber's nest as her storehouse; another individual of the same species laboriously excavated a twenty-two-celled nest in the hardest of clay. The variation among individuals of *O. dorsalis* is not less striking. I was surprised when I found that this wasp dug its nest in two situations, as either in the side of a bank or in level ground. My surprise grew to astonishment when I read Mr. Hartman's account, stating that *O. dorsalis* also constructs cells above the ground. *O. arvensis,* too, varies widely in its choice of nesting sites; I found her to be a burrower in various situations, while Mr. Hartman credits her with building in convenient holes and crevices.

As far as I observed, *O. papagorum* is in many ways a dissenter from this rule of variation, at least in regard to nesting sites and the type of nest used. She appeared to have but one favored nesting site, and that was limited by a number of conditions. I believe her to be less plastic also in her other habits than the species mentioned. Yet within this most stable species variations were on every hand. For instance, consider the cells, their variability in number in a nest, in arrangement, and in the direction of their long axes. Or consider excep-

tions—the wasp that had not sufficiently subdued her caterpillar; the wasp that discarded the earth she excavated and stole fresh earth from the *Anthrophora* tube to build her own, or the wasp that struggled to carry earth into her nest, in spite of a windstorm that forced the other members of the colony to stop work. In many of the minor activities connected with the nest, the other species, as well as *O. papagorum,* showed a wide range of variability.

Yet these variations are not without a limit. There were in most cases certain habits, typical of a species—just as there are type specimens in structure and coloration for each species—about which the variations centered. As, for instance, while there might be a great difference between the shape of two cells of a species, representing the two extremes in variation; yet the majority of cells would be between the two extremes, and the difference between many of them could be known only by careful and minute measurements. Again, caterpillars in varying states of mobility were stored by individuals of a species; yet this difference in most instances can scarcely be known without a close comparison of individual caterpillars. I know of no mean between the two extreme types of nests of *O. dorsalis*—the burrow, and the cells above ground; perhaps when our knowledge of this species is more complete this mean will be found.

In spite of this variability in many habits, there were certain other habits that characterized the family—habits that seemed inflexible and that occurred in all the species observed. There were certain other fixed characteristics that belonged only to a species or to a genus. In the genus *Odynerus* the wasps do not turn around in the nest; if a wasp has gone into a nest head foremost it comes out backwards. All that I observed used water in nest-building. Members of this genus always take wing after taking out a pellet from a burrow, and drop the pellet while in the air. I have noted no variations from these habits.

I shall mention some of the habits of the family that are least flexible of those I noted. The food of the wasp grub was always a plant-feeding larva. With no exception, all of the lepidopterous larvæ whose environment I observed or that I have read of were spinners. Why such should be preferred I can not imagine. As far as I observed, the caterpillar was always carried in the same way—its head foremost and its

ventral side up. All the eumenids suspend their eggs by filaments from the cell wall. A single individual of *O. dorsalis* violated this rule, possibly accidentally, by attaching an egg to the caterpillar. When floating on water or at work elsewhere a eumenid's wings are always held open and at oblique angles to its thorax; it is always in position to take flight at any moment.

These habits were conspicuous among the activities of the wasps that I observed, because of their uniformity both among the species and the individuals. To me they have seemed to be invariable characteristics of the Eumenidæ.

BIBLIOGRAPHY.

ALFHEN, G.
1892—O. murarius; habits. Ent. Nachr. XVIII, p. 270.

ASHMEAD, W. K.
1894—Habits of Eumenidæ. Psyche, pp. 76 to 78.
1897—O. albophalertus. Psyche, p. 335.

AURIVILLIUS, C.
1886—O. murarium; nests, habits, and metamorphoses. Bit So. Ak. Handl. XII, pp. 4-5.
1888—O. murarius. Oefi. Ak. Tork, p. 608.
1888—O. bifaciatus. Oefi. Ak. Tork, p. 610.
1905—Vespidæ and Eumenidæ of Sweden. Ent. Tedskr. XXVI, pp. 209-232.

ALDERZ, GOTTFRID.
1907—Eumenes coaretata; habits. Ark. Zool. III, No. 17, pp. 1-3.
1907—O. murarius and O. bifaciatus; habits. Ark. Zool. VII, No. 17, pp. 39-53.

BERG, C.
1900—Apuntes sobre das expecies del genero Odynerus de la Tierra del Fuego. Comm. Mus. Buenos Aires, pp. 232-240.

BIGNELL, G. C.
1881—O. pictus; note on nest and larvæ. Ent. XIV, pp. 188-189.
1882—O. pictus; transformations noticed. Ent. XIV, p. 164.

BILLUPS.
1883—O. reniformis; note. Ent. M. M. XVI, pp. 68-69.

BINGHAM, C. T.
1889—E. conica; habits. J. Bombay Soc. XII, p. 585.

BONNEFOIS, A.
1894—E. pomiformis; habits of larvæ. Ann. Ent. Soc. Fr., pp. 8-11.

BORRIES.
1897—A. ovivantris. Natural history, Vid Medd, pp. 160-163.

BRETHES, J.
1902—O. argentinus; nesting habits. Revist. Mus. La Plata X, p. 204, pl. I.

BRUCH, CARLOS.
1904—Le nid de l Enmenes caniculata (Sauss.) et observations sur deux de ses parasites. Revist. Mus. La Plata XI, pp. 317-323, pls. I-III.

CARPENTIER, L.
1889—O. spinipes L; habits. Mem. Soc. L. N. Fr. VII, 67-69.
1892—O. spinipes L; parasites. Bull. Soc. L. N. Fr. X, p. 326.

CHRETIEN, P.
1896—E. pomiformis, E. arbustorum and O. spiricornis; habits. Bull. Soc. Ent. Fr., pp. 410-411.
1897—E. pomiformis. Naturaliste, pp. 35-37.

COMSTOCK, J. H.
1904—Eumenidæ. Manual for Study of Insects, pp. 658-660.

CRETON, E.
1903—Some observations on E. dimidiatipennis. J. Bombay Soc., 820-823.

DAVIDSON.
1899—Ancistrocerus birenimaculatus; habits. Ent. News X, p. 180.

DE SAUSSURE, HENRI.
1875—Synopsis of American wasps. Sm. Misc. Coll., No. 254.
1899—Biology of Madagascar wasps. Abb. Sanckenb. Ges. XXVI, pp. 203-246.

DUFOUR, LEON.
1838—Memoire pour servir a l'histoire de l'industrie et des metamorphoses des Odyneres. Ann. Sc. Nat., ser. 2, vol. 11, 2.

ESCALERA, MANUEL M. DE LA.
1910—E. arbustorum; habits. Assoc. Espan. 4, ser. 3, p. 351.

ESCHER-KUNDIG.
1902—E. amedei; notes on habits. Mt. Schweiz. Ent. Ges. X, p. 374.

FABRE, J. HENRI.
1883—E. amedei, E. pomiformis and allies; architecture, habits of larvæ, etc. Nouv. Souv. Ent., pp. 57-58.
1883—Odynerus. Nouv. Souv. Ent., pp. 78-98.
1891—O. nitulator; habits. Souv. IV, chap. X.

FERNTON, C.
1896—Observations sur l'instinct de quelques Hymenopteres du genre Odynerus. Act. Soc. Lin. Bordeaux 48, pp. 219-220.
1902—E. pomiformis; oviposition, larval habits. Ann. Soc. Ent. Fr., pp. 521-527.

FRIESE, H.
1895—E. pomiformis; larva destroyed by Mesotemus. Ent. Nachr. XXI, p. 123.

FROGGART, W. W.
1894—Abispa splendida; habits. P. Linn. Soc. N. S. Wales IX, p. 29.

GIRAUD, J.
1865—Economy of three species of Odynerus inhabiting dry bramble twigs. Ann. Soc. Ent. Fr. (4), ser. XI, pp. 463-466.

GRIBODO, G.
1897—Eumenes; notes on East African species. Mem. Acc. Bologna, pp. 89-93.

HORNE, CHARLES.
1871—E. conica, E. esuriens and O. punctum. Tr. Z. S. VII, pp. 166-168.

HARTMAN, CARL.
1905—O. dorsalis, arvensis. Bull. Univ. Tex., No. 65, pp. 6-10.

HOPPFNER, H.
1902—O. exilis, lævepipes; nesting habits. Allg. Zeitchr. Ent., pp. 180-184.

HOWARD, L. O.
1905—The Eumenidæ. Insect Book, pp. 30, 31.

HUNGERFORD, H. B., AND WILLIAMS, F. X.
1912—O. annulatus, geminus, foraminatus. Ent. News, XXIV, pp. 250-255.

KELLOGG, V. L.
1904—American Insects, pp. 498-502.

KING.
1892—O. muriarius. Sci. Goss., pp. 196-198.

KRIECHBAUMER.
1879—Eumeniden Studien. Ent. Nachr. V, pp. 1-4, 57, 59, 85, 89, 201, 204, 309-312.

LALOY, L.
1905—Les Odyneres. Naturaliste, 273-275.
1906—Les Eumenes. Naturaliste, 153, 154.

LICHTENSTEIN, J.
1872—O. crassicornis; habits. Bull. Ent. Soc. Fr. (5) IV, p. 86.
1879—E. amedei; noticed. Pet. Nouv. XI, p. 311.

LUCAS, N.
1877—E. germaini. Ann. Soc. Ent. Fr. (5) VI, 300.
1877—E. germaini; transformations. Bull. Ent. Soc. Fr. (5) IX, p. 45.

LUCAS, N., AND LICHTENSTEIN, J.
1883—E. amedii; nidification described. Bull. Soc. Ent. Fr. III, p. 93.

MAINDRAN, M.
1882—Histoire des Guepes solitaires de l'Archipel Indien et de la Nouvelle Guinee. Ann. Soc. Ent. Fr. (6) II, pp. 69-71, 169-188, 267-286, pls. III, V.

MANTERNO, GIACOMO.
1910—Illustrazione dei nidi di aluni Eumendi americani possedute dal Museo Civico di nat di Genova. Ann. Mus. Genova 4, pp. 539-541.

MARLATT, C. L.
1894—Food habits of Odynerus. Proc. Ent. Soc. Wash., vol. VI, 3, pp. 172, 173.

MORICE, T. D.
1906—Nidifications of O. reniformis. Ent. Mag. III, pp. 216-218.

PECKHAM, G. W., AND E. G.
1905—Habits of six of genus Odynerus. Wasps, Social and Solitary, pp. 89-95.

PEREZ, J.
1895—O. reaumurii and a Cripted; relations as regards food. Bull. Soc. Ent. Fr., p. 254.

PERKINS, R. C. L.
1899—Eumenidæ. Faun Hawaiiensis, vol. I, part 1, pp. 30, 31.

RADOSZKOWSKI.
1887—O. ornatus; note. Hor. Ent. Ross. XXI, p. 100.

REGINHART, M.
1874—O. rubicola; habits and metamorphoses. Feuil. Nat. No. 44, p. 899.

RILEY, C. V.
1870—Odynerus; habits and parasites. Am. Ent. III, p. 154.
1883—E. fraterna; destructive to canker-worms. Rep. U. S. Ent. Comm. III, p. 177, fig. 3.

RUDOW.
1894—E. arbustorum, poniformis, coaretatus; nests. Ent. VIII, pp. 59, 60.

SAUNDERS, E.
1879—Notes on British species of the genus Odynerus. Ent. M. M. XV, pp. 249, 250.

SAUNDERS, W.
1882—E. fraterna; note. Rep. Fruit Growers' Ass. Ont., p. 281.

SHARP, DAVID.
1909—Eumenidæ. Camb. Nat. Hist., vol. VI, pp. 72-78.

SOUTHWICK.
1892—E. fraterna; habits. Ins. Life V, p. 107.

TANDY, M.
1908—Monobia quadridens. Ent. News 19, pp. 231-232.

VAN JHERING.
1892—Nortonia sp., modification. Congr. Zoöl. 1, p. 251.

VERHOEFF, C.
1889—O. parietum; varietal note. Ent. Nach. XVI, p. 337.
1891—Pt. spinipes, Pt. lævipes; biology. Verh. Ver Rheinal XLVIII, pp. 15-16, 40-57.
1893—Dufour's memoir on habits translated into German, with remarks. Ent. Nach. XIX, pp. 49-54, 65-74.
1893—O. parietium; habits. Berlin Ent. Zeitschr. XXXVII, pp. 467-478.

XAMBEAU, P.
1907—Nidifications des Eumendies. Naturaliste 29, pp. 57-58.